MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXXXVI. FEBRUARY 12, 1926. NO. 4

ANNUAL GENERAL MEETING.

Dr. J. H. JEANS, PRESIDENT, in the Chair.

The Minutes of the preceding Annual General Meeting were read and confirmed.

The Report of the Auditors of the Treasurer's accounts for the year 1925 was read, and is given on p. 169.

The Annual Report of the Council was partly read.

The Address was delivered by the President, after which the Gold Medal was handed to the Foreign Secretary for transmission to Professor Albert Einstein, to whom the Medal had been awarded for his Researches on Relativity and the Theory of Gravitation.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 270.

The thanks of the Meeting were given to the retiring Members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

Frederick Addey, B.Sc., M.I.E.E., Assistant Inspector of Wireless Telegraphy, G.P.O., Ryecroft, Chinbrook Road, Grove Park, London, S.E.12 ;

Alexander Williams Anderson, Commander R.N.R., G.H.Q., British Army of the Rhine ;

Ernest Anthony Lonsdale Attkins, London District Manager's Dept., London and North Eastern Rly. Co. and 2 Outred Villas, Squirrels Heath, Essex ;

C. M. C. Bone, M.A., Surveyor General's Office, Pretoria, South Africa ;

Dr. Willem Hendrik van den Bos, Leiden Observatory, Holland, and Union Observatory, Johannesburg, South Africa ;

William Stephen Finsen, Union Observatory, Johannesburg, South Africa ;

David Lamont Forbes, 437 Smith Street, Durban, Natal, South Africa ;

Capt. Henry Freyne, Nautical Surveyor and Examiner of Masters and Mates for the Irish Free State, 27 Eden Quay, Dublin, Ireland ;

Frederick Gawith, Hawera, New Zealand ;

Rev. Herbert Hedley, M.A., 17 Brockhill Road, Hythe, Kent ;

W. W. Heinrich, Observatoire de l'Université tchèque, Prague-Smíchov, Czechoslovakia ;

Kiyotsugu Hirayama, D.Sc., Professor of Astronomy at the Imperial University of Tokyo, Astronomical Observatory, Azabu, Tokyo, Japan ;

Alan Patrick Mackerras, B.E., International General Electric Co., Schenectady, New York, U.S.A. ;

Sydney Briton Henry Manning, McLaren Flat, South Australia ;

William Ralph Mechaelis, Head Master of the Alexandra District High School, Alexandra, Otago, New Zealand ;

Zeus A. Merfield, Research Physicist, University, Melbourne, Victoria, Australia ;

Patrick O'Dea, M.A., LL.B., Hawera, New Zealand ;

William Tyler Olcott, Norwich, Connecticut, U.S.A. ;

C. Parvulesco, Plœsti, Roumania ;

Frederick Charles Pilcher, Survey of India, Belmont, Norris Road, Richmond Town, Bangalore Cantonment, South India ;

Alexander Oliver Rankine, O.B.E., D.Sc., Director of Technical Optics Dept. and Professor of Physics, Imperial College of Science and Technology, London, S.W.7 ;

N. M. Shah, M.A., Principal of the New Poona College, Poona City, India ;

William Francis Herschel Waterfield, Nakusp, British Columbia, Canada ; and

W. H. Watts, B.Sc., the Lydiate, Heswall, Cheshire,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Arthur Tasker Burnell, Ribstone House, Sydney Road, Friern Barnet, London, N.10 (proposed by J. S. Fletcher) ;

James Chilton Dobbie, B.A., 229 Gloucester Terrace, Paddington, London, W. (proposed by L. N. G. Filon) ;

John William Harmer, B.A., Marlborough College, Wilts (proposed by H. Jeffreys) ;

Charles William Jeffries, Royal Observatory, Hong-Kong (proposed by F. W. Dyson) ;

P. Samuels Lall, M.A., Professor, Forman College, Lahore, and Curator, Punjaub University Observatory, Lahore, India (proposed by T. E. R. Phillips) ;

Vita Ermenilda Elvira Sharpe, Rosemead, Littlehampton, Sussex (proposed by E. J. Sharpe) ;

Duncan McLaren Young Sommerville, M.A., D.Sc., Professor of Mathematics, Victoria University College, Wellington, New Zealand (proposed by L. J. Comrie) ; and

Hugh Chaloner Woods, B.Sc., Oakhurst, Blindley Heath, Surrey (proposed by L. N. G. Filon).

Report of the Council to the Hundred and Sixth Annual General Meeting of the Society.

Progress and Present State of the Society.

	Patron	Institutional Member	Honorary Member	Fellows: Compounders	Fellows: Annual Subscribers	Associates	Total
1924 December 31	1	1	1	226	637	47	913
Since elected	...	...	...	+3	+44	+2	...
Deceased	...	...	...	−6	−16	...	...
Resigned	...	...	...	...	− 8	...	...
Since compounded	...	...	...	+4	− 4	...	...
Removed from list	...	...	...	...	− 9	...	...
1925 December 31	1	1	1	227	644	49	923

(Four Associates are also Fellows, and are therefore counted twice in the above table.)

Colonel Stratton's Cash Account as Treasurer of the Royal

RECEIVED.

	£ s. d.	£ s. d.
Received on account of Dividends:—		
£1,250 Metropolitan 3-per-cent. Stock (Tax free) ...	37 10 0	
£2,000 Swansea Corporation 3½-per-cent. Stock (Tax free)	70 0 0	
£2,287, 6s. 9d. East Indian Railway 3-per-cent. Debenture Stock	54 9 1	
£5,125 London Midland and Scottish Railway 4-per-cent. Debenture Stock	160 3 1	
£750 London Midland and Scottish Railway 4-per-cent. Consolidated Preference Stock	23 8 9	
£2,400 Gas Light & Coke Co. 3-per-cent. Debenture Stock	56 5 0	
£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock	47 11 3	
£3,852, 12s. 6d. War Loan Inscribed 5-per-cent. Stock (Tax free)	192 12 6	
Interest on Deposit Account (proportion)	5 16 7	
Income Tax refunded £106 4 2		
Less apportioned to Trust Funds ... 7 10 0		
	98 14 2	
Sale of Publications:—		746 10 5
Monthly Notices, Memoirs, History, etc.:—		
At Society's Rooms 68 9 11		
At Wheldon & Wesley's 244 0 9		
	312 10 8	
Herschel Papers	2 0 0	
Reprints	100 14 7	
Franklin Adams Charts	10 0 0	
Slide Catalogue	2 4 0	
Miscellaneous Receipts:—		427 9 3
Sale of Photographs	66 13 0	
Postages and Packing repaid	19 15 1	
London Mathematical Society, for use of Rooms, etc.	30 0 0	
Use of Telephone	0 4 1	
Assistant Secretary and Clerk, Pension Premiums ...	19 5 0	
Sale of Scrap Iron	0 2 0	
British Association, repayment for Circular	0 10 0	
		136 9 2
Trust Fund Dividends:—		1310 8 10
£1,212, 13s. 3d. East Indian Railway 3-per-cent. Debenture Stock	28 17 8	
Income Tax on ditto, refunded	7 10 0	
£542, 18s. 2d. India 3½-per-cent. Stock (Tax free) ...	19 0 0	
£946, 6s. 11d. 5-per-cent. War Stock, 1929/47 (Tax free)	47 6 4	
Special Fund:—		102 14 0
Donations in 1925	14 0 6	
Interest on National War Bonds	50 0 0	
Interest on Deposit Account (proportion)	5 0 11	
Received on account of Subscriptions:—		69 1 5
484 Annual Contributions for 1925 (including 1 Institutional Membership fee)	1016 8 0	
12 Annual Contributions 1926, paid in advance ...	25 4 0	
44 Admission Fees (including 1 due in 1924)	92 8 0	
41 First Contributions (including 1 due in 1924) ...	71 8 0	
Arrears paid off:—		
3 for 1922 ... ... £6 6 0		
18 for 1923 ... ... 37 16 0		
54½ for 1924 ... ... 114 9 0		
	158 11 0	
		1363 19 0
Compositions		185 17 0
Balances, 1925 January 1:—		
Cheques outstanding, 1925 Jan. 1	1 5 0	
In hand of Assistant Secretary on Petty Cash Account	22 13 2	
At Bankers', on Current Account, as per Pass Book ...	254 12 1	
At Bankers', on Deposit Account (including £341, 9s 4d., Special Fund)	491 3 0	
At Bankers', on "C" Account (Trust Funds) ...	104 5 4	
		873 18 7
		£3905 18 10

Examined and found correct.

(Signed) HERBERT DINGLE.
FRANK ROBBINS.

1926 *January* 21.

Astronomical Society, from 1925 *January* 1 *to December* 31.

PAID.

	£ s. d.	£ s. d.
Assistant Secretary: Salary	225 0 0	
Clerk: Salary	160 0 0	
Assistant Secretary and Clerk for work for London Mathematical Society in 1024	10 0 0	
Pension Premiums for Assistant Secretary and Clerk ...	57 15 0	
Porter and Cleaner: Wages	130 1 0	
Health Insurance	0 9 2	
Gratuity to J. Barrett	12 10 0	
Pensions, J. and Mrs. Barrett, Aug. 24–Dec. 31	27 10 0	
		623 5 2
Fire and Accident Insurance	15 14 3	
Telephone	12 1 6	
Registration of Telegraphic Address	2 0 0	
Time Signal	5 2 8	
		34 18 5
Postage and Packing (including postage of *Monthly Notices*, £104, 16s. 11d.)		160 10 6
Printing, etc.:—		
Monthly Notices (9 numbers)	1245 19 0	
Memoirs, 64, pt. 1	43 8 9	
List of Fellows, Slide Catalogue and Miscellaneous ...	118 14 4	
Reprints	106 6 0	
Photo-engraving	79 11 6	
		1593 19 7
Reproduction of Photographs for sale		83 3 8
Library Equipment	1 16 3	
Royal Society, half share of Profits on Herschel Papers	1 0 0	
Stationery and Office Expenses	20 12 10	
Coal, Gas, Electric Light	91 8 11	
House Cleaning, Laundry, etc.	17 7 0	
Furniture, Fittings, and Repairs	62 14 5	
Porter's Uniform, etc.	7 6 6	
Subscription to International Telegrams Bureau, 1924–26	3 16 9	
Five Gold Medals	51 5 0	
Purchase of scarce numbers of *Monthly Notices*	0 15 6	
Purchase of 1 set of Franklin-Adams Charts	10 0 0	
Miscellaneous Expenditure	16 12 1	
Expenses of R.A.S. Meetings	23 19 11	
Expenses of Geophysical Discussions	5 0 5	
Expenses of L.M.S. Meetings	6 2 1	
		319 17 8
Bank Charges and Cheque-Book		1 4 4
		2816 19 4
Purchase of £419, 17s. 11d. Conversion Loan 4½-per-cent Stock (Special Fund)		400 0 0
Expenditure on Trust Accounts:—		
Turnover and Horrocks Fund } Library	15 0 5	
Harry Watson Fund ... }	53 1 4	
		68 1 9
Balances, 1925 December 31:—		
Cheques not yet credited	6 6 0	
In hand of Assistant Secretary on Petty Cash Account	13 16 2	
At Bankers', on Current Account, as per Pass Book	170 15 0	
At Bankers', on Deposit Account (including Special Fund £10, 10s. 9d.)	291 3 0	
At Bankers', on "C" Account (Trust Funds) ...	138 17 7	
		620 17 9
		£3905 18 10

REVENUE

	£	s.	d.	£	s.	d.
To General Expenditure as per Cash Account	2816	19	4			
,, Reserve for Accounts due but not presented	265	0	0			
	3081	19	4			
Less Reserve for Accounts due 1924 now written back	260	0	0			
				2821	19	4
,, 38 Annual Contributions in Arrear written off ...	79	16	0			
,, 12 Annual Contributions 1925 written off as per contra	25	4	0			
				105	0	0
Excess of Income over Expenditure, 1925	...		...	49	14	5
				£2976	13	9

ACCOUNT, 1925.

		£	s.	d.	£	s.	d.
By Subscriptions—							
484	Annual Contributions for 1925 (including 8 from Fellows elected 1925 January, and 1 Institutional Membership Fee)	1016	8	0			
13	ditto, paid in advance in 1922–24, and now matured	27	6	0			
123	ditto, outstanding	258	6	0			
12	Contributions for 1925 due, but unpaid, in respect of Fellows resigned, died, or names removed, and written off per contra ...	25	4	0			
632					1327	4	0
,, 27	First Contributions, 1925, at 2 guineas ...	56	14	0			
13	ditto, at 1 guinea	13	13	0			
4	ditto, outstanding	4	4	0			
44					74	11	0
,, 43	Admission Fees, 1925	90	6	0			
4	ditto, outstanding	8	8	0			
47					98	14	0
3	Composition Fees (initial)	94	10	0			
4	Since compounded	91	7	0			
7					185	17	0
,,	Sundry Debtors, 1925	...		...	57	0	4
,,	Dividends, Sales of Publications, and Miscellaneous Receipts, as per Cash Account	1310	8	10			
Less	Payments due in 1924 (£77 19 2 *less* £5 16 9 still outstanding) ... £72 2 5						
	Income Tax repaid on 1924 Revenue 65 15 3						
		137	17	8			
					1172	11	2
,,	Income Tax deducted, but outstanding, 1925 April–December				60	16	3
					£2976	13	9

Examined and found correct.

(Signed) HERBERT DINGLE.
FRANK ROBBINS.

1926 *January* 21.

BALANCE SHEET,

LIABILITIES.

	£	s.	d.	£	s.	d.
2 Subscriptions 1926, paid in 1924	4	4	0			
12 Subscriptions 1926, paid in 1925	25	4	0			
				29	8	0
Sundry Creditors for Accounts due but not presented ...				265	0	0
Cash Balances (Income) due to Trust Funds—						
Turnor and Horrocks Fund	2	17	9			
Harry Watson Fund	54	18	5			
Hannah Jackson Fund	52	18	3			
Lee and Janson Fund	28	3	2			
				138	17	7
Trust Funds (Capital), as per contra				1,949	17	0
Special Fund—						
As at 1924 December 31	1,414	5	9			
Donations and Interest, 1925	69	1	5			
				1,483	7	2
General Fund—As at 1924 December 31	15,636	2	4			
Add—Excess of Income over Expenditure, 1925 ...	49	14	5			
				15,685	16	9
				£19,552	6	6

227 Compounders.

Examined and found correct.

(Signed) HERBERT DINGLE.

FRANK ROBBINS.

1926 *January* 21

1925 *December* 31.

ASSETS.

	£ s. d.	£ s. d.
Sundry Debtors for Subscriptions in Arrears—		
13 for 1923	27 6 0	
47¼ for 1924	99 5 0	
123 for 1925	258 6 0	
4 First Contributions for 1925, outstanding ...	4 4 0	
4 Admission Fees for 1925, outstanding	8 8 0	
		397 9 0
Sundry Debtors, 1922	1 13 0	
,, ,, 1924	5 16 9	
		7 9 9
Sundry Debtors, 1925—		
Due for Publications sold (including Reprints) ...	18 1 0	
Due from Wheldon & Wesley for Publications sold during the last quarter of 1925	32 14 1	
Due for Photographs sold	2 3 0	
Due for Postages and Packing-cases	4 2 3	
		57 0 4
Investments, General Fund, valued as on 1922 December 29		14,986 0 0
Investments of Special Fund, valued as at date of purchase—		
Two £500 National War Bonds 1927–1929	1,072 16 5	
£419 17s. 11d. Conversion 4½% Stock 1940–44 ...	400 0 0	
		1,472 16 5
Investments of Trust Funds, valued as on 1922 December 29 or date of purchase if later		1,949 17 0
Income Tax deducted, 1925 April–December		60 16 3
Sundry Balances—		
Cash at Bank on Current Account	170 15 0	
,, ,, Deposit (including Special Fund, £10, 10s. 9d.)	291 3 0	
,, ,, "C" Account (Trust Funds) ...	138 17 7	
Cash in hand of Assistant Secretary	13 16 2	
Cheques not credited, 1925 December 31	6 6 0	
		620 17 9
		£19,552 6 6

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, etc.

Stock of Publications and Photographs.

Five Gold Medals.

INVESTMENTS.

As at 1925 December 31.

GENERAL FUND.

£1250 Metropolitan 3-per-cent. Stock.

£2000 Swansea Corporation 3½-per-cent. Stock.

£2287, 6s. 9d. East Indian Railway 3-per-cent. Debenture Stock.

£5125 London, Midland, and Scottish Railway 4-per-cent. Debenture Stock.

£750 London, Midland, and Scottish Railway 4-per-cent. Consolidated Preference Stock.

£2400 Gas Light and Coke Co. 3-per-cent. Debenture Stock.

£2000 Commercial Gas Co. 3-per-cent. Debenture Stock.

£3852, 12s. 6d. War Loan Inscribed 5-per-cent. Stock, 1929–47.

SPECIAL FUND.

£500 National War Bonds, 1927.

£500 National War Bonds, 1929.

£419, 17s. 11d. Conversion 4½-per-cent. Stock, 1940–44.

TRUST FUNDS.

£1212, 13s. 3d. East Indian Railway 3-per-cent. Stock.

£542, 18s. 2d. India 3½-per-cent. Stock.

£946, 6s. 11d. War Loan Inscribed 5-per-cent. Stock, 1929–47.

Report of the Auditors for the Year 1925.

We have examined the Treasurer's account of receipts and expenditure, and the revenue account and balance sheet, for the calendar year 1925, and have certified these accounts to be correct.

The balance in hand on 1925 December 31 amounted to £620, 17*s.* 9*d.* This figure includes £138, 17*s.* 7*d.* Trust Funds, and £10, 10*s.* 9*d.* Special Fund.

The Balance Sheet shows that on 1925 December 31 the amount of the General Fund was £15,685, 16*s.* 9*d.*

The Revenue Account shows that the income for the year amounted to £2976, 13*s.* 9*d.*, and the expenditure to £2926, 19*s.* 4*d.*, giving an excess of income over expenditure equal to £49, 14*s.* 5*d.*

The investment holdings have been verified by the Bank of England and the Westminster Bank respectively.

The conditional pensions granted to the late porter and his wife have laid upon the funds of the Society a new responsibility of £78 per annum. The current accounts include £27, 10*s.* 0*d.* under this head for the period August 24 to December 31. Another new item of annual expenditure is a contribution of £16, being two-thirds of the annual premium to secure for the clerk a deferred annuity to commence at age 60. A contribution of £22, 10*s.* per annum for a similar purpose on behalf of the assistant secretary was initiated two years ago.

The increase of £271, 1*s.* 1*d.* in the cost of printing the *Monthly Notices* is due to the enlarged size of the volume for the year; the cost per page has remained practically the same as before.

A sum of £400 from the Grove-Hills Special Fund has been invested in 4½ per cent. Conversion Loan, the first instalment of interest being due on 1926 January 1.

The average rate of interest earned by money placed on deposit was £2, 11*s.* 6*d.* per cent., and by the whole investments (General, Special, and Trust), £3, 9*s.* 3*d.* per cent. Although this is a very low return it is not likely to increase. We suggest the provision of a reserve to cover the depreciation of securities, and a further reserve to meet future expenditure for renovation of the Society's premises.

The books, instruments, and other effects appear to be in a reasonably good condition. There are still six books missing, as reported a year ago. The work of rearranging the library has been completed, and the Assistant Secretary is now engaged in preparing a supplementary catalogue to cover the additions to the library during the period 1898–1925.

A list has been placed on the table of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

The number of outstanding subscriptions for the year 1925 amounted at the end of the year to 123.

We are indebted to the Assistant Secretary for the facilities that have been placed at our disposal during the Audit.

(Signed) Herbert Dingle.
Frank Robbins.

1926 *January* 21.

Gifts to the General Funds of the Society.

The John Lee Gift: In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2,000 Consols.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The Knott Gift (1899): Mrs. George Knott presented to the Society the sum of £250, to defray the cost of printing *Memoirs*, vol. lii., containing the late Mr. Knott's Observations of Variable Stars.

The Peek Bequest (1904): Sir C. E. Peek bequeathed to the Society the sum of £200, as a contribution towards the expense of printing the Rousdon Variable Star Observations (*Memoirs*, vol. lv., part 1).

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2,000, free of legacy duty.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

The Brook Gift (1907): C. L. Brook, Esq., gave one-third of the cost of printing Pogson's Variable Star Observations (*Memoirs*, vol. lviii.).

The Gill Bequest (1914): Sir David Gill, K.C.B., F.R.S., bequeathed to the Society the sum of £250, in aid of Astronomical Research, in grateful remembrance of a like sum paid out of the funds of the Society in aid of his expedition to Ascension in the year 1877. In accordance with his wishes this bequest was expended to defray part of the cost of publishing vol. lxiii. of the *Memoirs*, containing the Theory of the Four Great Satellites of Jupiter.

The Parsons Gift (1922): The Hon. Sir Charles Parsons, K.C.B., F.R.S., gave to the Society £2,500 War Stock (1929–47), in memory of his father, the 3rd Earl of Rosse, who made the 6-foot Reflector, and who died 1867 October 31.

The Grove-Hills Bequest (1922): Colonel E. H. Grove-Hills, C.M.G., F.R.S., bequeathed to the Society, free of legacy duty, his collection of early Astronomical and Mathematical books up to the year 1700, together with a sum of £250 to cover the expenses incurred by the Society in connection with the books.

The Grove-Hills Special Fund: As already reported to the Society, the late Treasurer, Col. Grove-Hills, collected by his private efforts, with the approval of the Council, a Special Fund to meet the immediate financial difficulties of the Society. He aimed at securing £1800, and up to the present the total amount received from all sources is £1683, 7*s.* 2*d.*, of which £200 was transferred during 1923 to the General Fund to meet current expenditure, £1072, 16*s.* 5*d.* was invested in National War Bonds, and £400 has been invested this year in Conversion Loan 4½-per-cent. Stock, 1940–44.

	£	*s.*	*d.*		£	*s.*	*d.*
1925 Jan. 1. Cash Balance of Fund	341	9	4	1925. Purchase of £419, 17*s.* 11*d.* Conversion Loan 4½-per-cent. Stock	400	0	0
Donations in 1925 ...	14	0	6	1925 Dec. 31. Cash Balance on Deposit	10	10	9
Interest on National War Bonds and Deposit Account ...	55	0	11				
	£410	10	9		£410	10	9

The following is the list of donors to this Fund in 1925:—

W. Hall.
G. Innes.
E. H. F. Lawrence.
J. Moroney.

Trust Funds.

The Lee and Janson Fund: In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334, 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock.

	£	*s.*	*d.*		£	*s.*	*d.*
1925 Jan. 1. Balance of Fund	18	2	6	1925 Dec. 31. Balance of Fund	28	3	2
1925. Dividends, East Indian Railway ...	10	0	8				
	£28	3	2		£28	3	2

The Turnor Fund and the Horrocks Memorial Fund: In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464, 18*s.* East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38, 15*s.*, the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrocks: to this the Society added the sum of £55, 15*s.*, and the whole now stands in £103, 6*s.* East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the Library.

	£	s.	d.		£	s.	d.
1925 Jan. 1. Balance of Fund	0	17	2	1925. Purchase of Books ...	15	0	5
1925. Dividends, East Indian Railway ...	17	1	0	1925 Dec. 31. Balance of Fund	2	17	9
	£17	18	2		£17	18	2

The Harry Watson Memorial Fund: In 1920 Mrs. Watson presented to the Society the sum of £300 as a memorial to her late husband, Lieut.-Col. Harry James Watson, F.R.A.S., the interest on this sum to be used for the purchase of books for the Library, such books to be indicated by a special book-plate. This gift now stands invested in £542, 18*s.* 2*d.* India 3½-per-cent. stock. In 1923 Mrs. Watson bequeathed a further sum of £958, 17*s.* 0*d.* to the Society, which now stands invested in £946, 6*s.* 11*d.* 5-per-cent. War Stock 1929–47. The Council resolved that these two sums should together constitute a Trust Fund, to be designated *The Harry Watson Memorial Fund*, to be used for the purchase and binding of books.

	£	s.	d.		£	s.	d.
1925 Jan. 1. Balance of Fund	41	13	5	1925. Purchase of Books and Binding ...	53	1	4
1925. Dividends, India 3½ per cent.	19	0	0	1925 Dec. 31. Balance of Fund	54	18	5
Dividends, War Stock 5 per cent.	47	6	4				
	£107	19	9		£107	19	9

The Hannah Jackson (née Gwilt) Fund: In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309, 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£	s.	d.		£	s.	d.
1925 Jan. 1. Balance of Fund	43	12	3	1925 Dec. 31. Balance of Fund	52	18	3
1925. Dividends, East Indian Railway	9	6	0				
	52	18	3		52	18	3

Celestial Photographs.

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to the Fellows:—

R.A.S. Ref. No.

5. Neb. N.G.C. 628 (M 74) Pisces, 1899 Oct. 31, 36-in. Refl., Lick Observatory.
20. Neb. N.G.C. 628 (M 74) Pisces, 1920, 60-in. Refl., Mount Wilson Observatory.
75. Moon, Age 16½d., 1897 Nov. 11, 24-in. Eq. Coudé, Puiseux, Paris.
76. Moon, Age 26d., 1914 Aug. 17, 26-in. Refr., R. Obs., Greenwich.
103. Moon, Age 7¼d., 1904 Feb. 23, 24-in. Eq. Coudé, Puiseux, Paris.

R.A.S. Ref. No.

105. Moon, Age 12½d., 1904 Feb. 28, 24-in. Eq. Coudé, Puiseux, Paris.
345. Halley's Comet, 1910 May 7, Lowell Observatory.
346. Halley's Comet, 1910 May 13, Lowell Observatory.
347. Solar Corona, 1923 Sept. 10, Yerbanis, Mexico, 15 ft. camera, Sproul Observatory Expedition.
348. Comet 1911 V (Brooks), 1911 Oct. 22, 30-in. Refl., Helwân.
349. Comet 1911 V (Brooks), 1911 Oct. 28, 30-in. Refl., Helwân.
350. Comet 1911 V (Brooks), 1911 Nov. 3, 30-in. Refl., Helwân.
351. Halley's Comet, 1910 May 9, 30-in. Refl., Helwân.
352. Halley's Comet, 1910 May 10, 30-in. Refl., Helwân.
353. Halley's Comet, 1910 May 21, 30-in. Refl., Helwân.
354. Halley's Comet, 1910 May 29, 30-in. Refl., Helwân.
355. Halley's Comet, 1910 May 31, 30-in. Refl., Helwân.
356. Halley's Comet, 1910 June 2 (Exp. 5 m.), 30-in. Refl., Helwân.
357. Halley's Comet, 1910 June 4, 30-in. Refl., Helwân.
358. Comparison of Nebular Spectra, 36-in. Refl., Lick Observatory.
359. Spectrum of Annular Nebula in Lyra, 36-in. Refl., Lick Observatory.
360. Typical Stellar Spectra, Pa Neb. Spectrum and O Stellar Spectra, 37½-in. Refl., Curtiss, Michigan.
361. Typical Stellar Spectra, Bo to Go, 37½-in. Refl., Curtiss, Michigan.
362. Typical Stellar Spectra, G5 to Md, 37½-in. Refl., Curtiss, Michigan.
363. Typical Stellar Spectra, G, R, and N, 37½-in. Refl., Curtiss, Michigan.
364. Spectrum of Chromosphere at Sun's Limb, Eclipse 1898, Visiadrug, India, 6-in. prismatic camera, Fowler.
365. Spectrum of Corona, Eclipse 1905, Sfax, Tunis, 2-prism slit spectroscope, Dyson.
366. Neb. N.G.C. 253, H.V.I. Cetus, 1907 Nov. 7, 36-in. Refl., Lick Observatory.

Publications of the Society.

During the past year the Society has published *Monthly Notices*, vol. lxxxv., *Geophysical Supplements*, No. 6, *Memoirs*, vol. 64, pt. 1, and *Catalogue of Reproductions of Celestial Photographs.*

Obituary.

The Council regret that they have to record the loss by death of the following Fellows during the past year :—

Fellows :—Bertram Bennett.
William L. E. Bennett.
Aloysius L. Cortie.
John Crouch.
*Arthur Dallas.
Camille Flammarion.
William Bolger Gibbs.
Raymond H. Godfrey.
John Laver.
Frederick C. Lees.
Henry Curwen Lord.
†Ernest E. Markwick.
Reginald C. Nelson.
Benjamin Noble.
Ole T. Olsen.
A. E. Brisco Owen.
John A. Parkhurst.
‡Howard Payn.
William Peck.
William Petersen.
David L. Salomons.
Charles B. Shaw.
Walter R. Stokes.

Bertram Bennett, the fourth son of W. C. Bennett, LL.D., was born at Greenwich on 1864 April 18. His early education was at St. Olave's School in London, and from this school he went to the Royal Observatory at Greenwich as a computer in 1880, in which position he remained for five years. In 1885 he entered St. Peter's College, Cambridge, where he took a prominent part in many forms of athletics. He obtained honours in the Mathematical Tripos, graduating B.A. in 1888 and M.A. in 1892.

He married, on 1892 August 24, Marian Elizabeth Taylor, daughter of the late Dr. John Taylor of Ticehurst, Sussex, and a few months later he took over the headmastership of Montpelier School, Paignton, which he successfully conducted to within a few days of his death. He died on 1925 March 21, leaving a widow, two sons, and two daughters.

He was elected a Fellow of the Society on 1892 February 12.

William Lionel Edgar Bennett, son of Mr. John Bennett of Hove, was born at Littlehampton on 1896 August 18. He studied at Christ's College, Cambridge, where he obtained 1st Class honours in the

* Died in 1924, but death not reported till 1925.
† For obituary notice, see p. 270.
‡ Died in 1921, but death not reported till 1925.

Mathematical Tripos. He was also a B.Sc. of London. He took up teaching and went to Dulwich College as Mathematical Master, where he died, after a short illness, from influenza on 1925 February 12.

He was elected a Fellow of the Society on 1923 January 12.

The Rev. Aloysius Laurence Cortie, S.J., Director of the Stonyhurst College Observatory, was born in London on 1859 April 22. He entered Stonyhurst as a boy in 1872 and remained until 1878, when he joined the Society of Jesus as a novice at Roehampton. In 1881 he took the London University course, and afterwards he spent three years in philosophical studies at St. Mary's Hall, Stonyhurst. From 1885 to 1889 he taught mathematics and natural science at Stonyhurst, before going to St. Beunos, where he was ordained in 1892. For a short time he was Prefect of Studies at the newly-founded College at Stamford Hill, but in 1895 he was back at Stonyhurst again to teach mathematics.

He succeeded Father Sidgreaves as Director of the Observatory in 1919, but he had already identified himself with eclipse work, having been to Spain in 1905, to Tonga Island in 1911, and to Sweden in 1914; he had also attended the meetings of the Solar Union at Meudon in 1907, at Mt. Wilson in 1910, and at Bonn in 1913: after the war he attended the meeting of the Astronomische Gesellschaft at Potsdam in 1921 and the meeting of the International Astronomical Union at Rome in 1922.

Early in 1925 he was attacked by influenza in a curious form: his temperature was normal by day, but for eight weeks it persisted in going up at night, and finally there came a stroke, and then another: his condition became grave, but could not destroy his cheeriness: to the doctor, who expressed sorrow that he could see no improvement, he replied: "Well, it is not *my* fault; I have taken all your medicines." But the end came on May 16.

It would be difficult in a notice of this kind to give an adequate idea of the place held by Father Cortie in astronomical circles, and let us boldly say in astronomical hearts: his presence and even his name were indissolubly linked with cheeriness, and seemed to "radiate sunshine." It was said of him that he had no acquaintances, for acquaintances became at once his friends; and he was once introduced by the chairman at one of his lectures in the words: "The lecturer will now address you—Father Cortie by name, courteous by nature." It is further recorded that at the end of one of the lectures an old woman was heard to remark, "my word, ain't he bonny?" Such characteristics are worth noting, if only for the reason that they are not usually associated in the popular mind with the Jesuit Order, of which, on the contrary, many hard things have been said, and to which many cruel things have been done. Astronomers have the good fortune to see a side of this devoted Order not perhaps usually seen by others: we in England remember the devoted life of Father Perry, who courageously undertook the expedition to Cayenne in 1889, losing his life by dysentery, though he secured photographs of the corona: and his successors at Stonyhurst have shown the same devotion to our science.

It may not be inappropriate to reproduce here the following para-

graph from the notice of Father Cortie in the *Times* of May 18 : " When the Jesuit Order was suppressed throughout the world in 1773 the great French astronomer Lalande said in an outburst of indignation : ' Carvalho and Choiseul have irretrievably destroyed the finest work of man, unrivalled by any human institution—the human race has lost that wonderful and invaluable assembly of 20,000 men, disinterestedly and unceasingly occupied with functions most important and most useful to man.' "

The devoted lives of such men as Father Cortie (and they are many) show us that the loss, however great, was fortunately not " irretrievable."

Father Cortie's work divided itself naturally into three parts, of which that on the connection of sun-spots with magnetic phenomena is the largest, the other two being his spectroscopic observations and his eclipse work. To take them in inverse order : his eclipse work was efficient, and properly completed : he measured the lines on the photographs of spectra obtained, and published the results with commendable promptitude. Similarly when a new star appeared the little spectroscope at Stonyhurst was prompt to secure observations, and to put them before the world at once. The *Monthly Notices* contain four papers on eclipses and a dozen on spectra of Novæ and other objects. But the papers on sun-spots number more than a score. They begin with the spots themselves as registered on the valuable series of Stonyhurst drawings, and Father Cortie shows that the positions deducible from these drawings are of creditable accuracy. Had we not had the systematic measures made at Greenwich, it is doubtful whether we could have found elsewhere an equivalent for the material represented by the long series of Stonyhurst drawings. But Father Cortie's attention was drawn to the connection of the spots with magnetic storms by Mr. Maunder's well-known work. There is still an old-world flavour about the curriculum at Stonyhurst and other Roman Catholic schools ; and Father Cortie's first paper in January 1905 opens characteristically with the remark that Mr. Maunder's syllogism is defective : " Even were he to prove his first premiss—namely, that magnetic storms mark out the synodic rotation-period of the sun—up to the hilt, it would still not follow logically that the cause of magnetic storms resides in the sun " : the alternative being (as suggested by Father Sidgreaves) that storms and spots may have a common cause which is neither on the sun nor on the earth. But in pursuing the investigation this alternative was abandoned in favour of an origin for the storms in the spots, but with the modification that a spot might send out several divergent streams of influence, any of which might cause a magnetic storm on the earth. The evidence for this view was collated with great patience in the series of papers above mentioned.

Father Cortie was a very successful lecturer, with ability to vary his style, so that practically the same lecture could be delivered to a scientific society or to the boys of a preparatory school. The Discussion Class of working men at Accrington twenty-four times in succession asked him to lecture : the discussion which followed the lecture was apt to stray a little from the particular topic—it mattered not whether

the lecturer had dealt with "A Trip to the South Seas" or "The Tail of a Comet"—in the discussion the members of the audience managed to air their views about "local option," "housing," or "tariff reform," until matters sometimes grew rather warm, when Father Cortie "replied." He told them a story or two, and the meeting dispersed peaceably, but was followed by a heavy supper, at which the discussion was continued. Contrast with this his addresses at Eton to a voluntary Nature Club for the members of the lower school, arranged by one of the house masters (Mr. Alan Ramsay). The audience was young, keen, and highly appreciative; and Father Cortie was at his best. On the last occasion the boys wrote him Latin letters about his lecture which were printed in the *Eton College Chronicle*; and the lecturer replied also in Latin, ending in the following words, which became unfortunately too significant in view of his death a few months later: "Spero fore ut, tempore aestivo, possim redire in aedes vestras, ad vos revisendos pro refectione meae saltem animae. Interim, ut utar exhortationibus piissimi fundatoris vestri, Henrici Sexti, beatissimae memoriae, 'Sitis boni pueri, mites et docibiles.' Sitis etiam servi Domini, ut tandem possimus omnes recipi in mansiones Illius, ubi ut stellae lucidae fulgeamus ad aeternitatem. Valete."

As a musician Father Cortie showed considerable ability. For nineteen years he was the Director of Music at Stonyhurst, and likewise a member of the Salford Diocesan Commission on Church Music. But outside this strictly professional work, his musical qualities were always at the service of his hearers, and always in demand. His voice was singularly flexible, and with his song he radiated sunlight amid the most uncongenial surroundings.

Finally, brief reference may be made to his influence as a preacher, especially at the meetings of the British Association, where a sermon from him at some available Roman Catholic church became a part of the regular programme from 1892 onwards. To quote another sentence from the *Tablet* for 1925 May 23, from which a few paragraphs have already been borrowed: "Each sermon was a scientific and theological argument, delivered to men and women who all that week had been engaged in a highly intellectual pursuit, and who were, in consequence, attuned to the apologetic which he then presented. This was true of England; it was true also of Toronto, Rome, Bonn, California, to all of which places he journeyed on scientific counts, and in all of which he proclaimed the Word of God as a priest and a scientist."

He was elected a Fellow of the Society on 1891 January 9.

H. H. T.

Rev. John Crouch, who died at Bridge of Weir on 1925 January 2, at the age of 84, was long connected with Paisley, where he was a Baptist Minister. He took an interest in several branches of science, and was a member of the Paisley Philosophical Institution for a very long period, served on its council for fifty years, and acted as president for the period 1908–11. He was a well-known lecturer in various subjects, but his principal attraction was towards astronomy. He served on the Committee of the Coats Observatory, Paisley, from its foundation in 1883.

He was a man of amiable character and kindly demeanour. His wide outlook on life and his great energy made him well known in the West of Scotland, where he was held in the highest esteem by all with whom he came in contact.

He was elected a Fellow of the Society on 1911 January 13.

Arthur Dallas was born at Shanghai on 1860 January 9. He was educated at a private school at Littlehampton, but returned to China and spent most of his life as an Architect and Civil Engineer in Shanghai. He married in 1890, and had a son and daughter, the former of whom, Captain Dallas, was killed in 1918. Mr. Dallas returned to England, and died on 1924 August 6 at St. John's Wood, London.

He was elected a Fellow of the Society on 1913 March 14.

Camille Flammarion was born at Montigny-le-Roi, in the department of Haute Marne, on 1842 February 26, and received his first call to astronomy at the early age of 5, on the occasion of the annular eclipse of the Sun of 1847, when the phenomenon was shown to him by his mother from the surface of a bucketful of water. Although, as he frequently related in after years, this event profoundly stirred his youthful imagination, and in all probability served to create the astronomer in him, his parents entertained quite other views regarding his future career, and intended him for the priesthood. But the *res angusta domi* did not permit of his receiving more than a very elementary education, and, at the age of 15, necessity drove him to Paris, where he was apprenticed to an engraver. Young Flammarion, however, like Faraday and other gifted natures, possessed that happy knack of turning apparently adverse circumstances to good account, so that by dint of night classes and his own innate industry he soon acquired a sufficient stock of ideas to prompt him, a year or two later, to write a lengthy MS. of 500 pages entitled *Cosmogonie Universelle*. It was this work (published long afterwards and greatly modified under the title *Le monde avant l'apparition de l'Homme*) which was the means of starting him on his official astronomical career. An admiring doctor, called in during an illness of Flammarion's, saw the work, and procured an interview with the great Le Verrier, then entering upon the fourth year of his directorship at the Paris Observatory. The result was Flammarion's appointment, in the year 1858, as a junior computer at a salary of 50 francs a month to begin with. At first his joy at achieving his heart's desire knew no bounds. In his enthusiasm the Avenue de l'Observatoire and the neighbouring gardens of the Luxembourg seemed a veritable paradise now that he fancied himself free to give full rein to his imagination and voyage in mind through all immensity, for it was the poetic aspect of astronomy that appealed to him most strongly. Disillusionment, however, came soon enough. Not only did he find the work assigned to him uncongenial, but the autocratic rule and unconciliatory manner of Le Verrier made his post at the Observatory anything but comfortable, so that he consoled himself in his leisure hours by giving full play to his fertile imagination in another lengthy MS. dealing this time with a journey to the moon. This effusion of the

young astronomer was never published, and, as he said of it himself afterwards, " il ne le mérite pas " ; but he scored a real literary success a year or two later with a work entitled *La Pluralité des Mondes habités.*

As in the case of the well-known classic of his great predecessor, Fontenelle, who in 1686 captured both the scientific and non-scientific world of letters with his famous *Entretiens sur la Pluralité des Mondes*, Flammarion's book proved an immediate and enormous success. But, although it made a considerable impression with the public at large, and ran into three editions in almost as many years, such literature was not to the liking of the austere Le Verrier, who curtly informed him that he could not remain at the Observatory, adding to his sentence of dismissal the unequivocal rider, " Rien n'est plus simple, Monsieur ; vous pouvez vous retirer ! "

Le Verrier's uncompromising measures, no less than his emphatic methods of enforcing them, were well known to his staff and heartily detested, so that this latest victim of the chief's wrath met with not a little sympathy both inside and outside the Observatory, and Flammarion consequently experienced no difficulty in obtaining a post at the Bureau des Longitudes on the same favourable terms as those he had been latterly receiving.

Flammarion by this time was already favourably known as a writer on astronomy, so that on leaving the Observatory in 1862 he found ample employment for his pen in the journalistic world. Thus, while still a young man, he became editor of the scientific review *Cosmos*, and commenced that active work as lecturer and populariser of his favourite science which was to make his name a household word throughout the civilised globe.

In 1864 he began the issue of his *Annuaire Astronomique*, a regularly appearing almanac which for a period now extending over sixty years has made the face of the sky familiar to thousands. This work, in conjunction with the ever popular and energetic Société Astronomique de France, which he called into being in 1887, and which was recognised as of public utility ten years later by the Republic, has probably done more for what the French call the " vulgarisation " of astronomy than any other agency of modern times. Flammarion counted his " élèves " by the thousand in all lands and in all circles, even amongst those who otherwise looked somewhat coldly on the divine science, for throughout his long career he consistently acted on the principle that without an emotional basis knowledge can never receive adequate recognition among the mass of mankind.

It cannot be denied that to those who read his works in translation (especially on this side of the Channel) the style of some of his more popular and imaginative books appears forced and flamboyant, but allowances must be made for the original medium—the French language —which, perhaps more than any other, lends itself to picturesque imagery as well as to spontaneity and subtlety of expression. It would be quite unfair, however, to judge our author by his more florid productions, and readers of his popular writings are probably quite unaware of his real contributions to science. Thus, his work on Mars, binary stars, and proper motions is of permanent value, and it has been

suggested that, had he pursued these researches, he might have forestalled many modern results now definitely associated with the names of other astronomers. Flammarion, as a matter of fact, was never able to concentrate intensively along a definite line of research, and it is chiefly for this reason that his reputation as a professional astronomer was occasionally called in question by the serious student. He was essentially an apostle of popular astronomy, and as such carried the light of his science into many a corner which otherwise would have remained dark.

The autocratic regime which led to Flammarion's dismissal from the Paris Observatory in 1862, and, indeed, gradually to the Director's own supersession between 1870 and 1873, came to an end on Le Verrier's reinstatement in the latter year, and it is only fair to add that he soon took occasion to recall Flammarion and place at his disposal one of the largest telescopes in the Observatory for the measurement of double stars. But Flammarion was soon to have an observatory of his own. This came in 1882, when an unknown admirer and wealthy landowner, M. Méret, conveyed to him some property at Juvisy-sur-Orge, not far from Paris. This Flammarion converted into an astronomical observatory, where he mounted the 9½-inch Bardou equatorial which figures so frequently in the reports printed in his review *L'Astronomie*, afterwards merged in the *Bulletin de la Société Astronomique de France*. Here, also, he made his home, devoting his time almost exclusively to purely observational astronomy free from the routine work which monopolises so large a portion of the professional programme.

Flammarion was twice married, his first wife being a widow, *née* Sylvie Petiaux-Hugo, who died in 1919, and his second, Mlle. Gabrielle Renaudot, who survives him, and who is also an astronomer.

Flammarion was a prodigious worker throughout his long life; and even on the day of his death, which took place in his study at Juvisy on 1925 June 3, he was preparing some notes for the bulletin of the Society he had founded thirty-eight years previously, and whose welfare he had so much at heart. These notes, it is interesting to learn, he was translating from an article in our English journal, *Nature*—a periodical he always held in high esteem, for he had mastered our language by himself when still a boy.

It is characteristic of his life's work that this last action of his was devoted to the interests of the object he held so dear, viz. the diffusion of a knowledge of, and a due appreciation of, the wonders of astronomy, and it is probably as the most enthusiastically successful expositor of his day that Camille Flammarion will be best remembered.

He was elected a Fellow of the Society on 1878 April 12.

W. A. P.

William Bolger Gibbs, who died on August 16 last at the advanced age of 91, was the oldest Fellow of the Society. In the announcement of his death in the daily press he was described as the "Father" of the London Stock Exchange, which indicates his occupation in life; but, apart from his business, Mr. Gibbs' tastes and inclinations lay in the direction of science, and he engaged himself in the pursuits of

mathematics, microscopy, geology, and especially astronomy. As a young man, after he had begun his career in the city, which he did at the age of 14, he attended the lectures of Augustus de Morgan at University College; and later, when he joined our Society, his nomination form was signed, "from personal knowledge," by Dr. William Rutherford, a former lecturer at the Royal Military Academy, with whom Gibbs for a time read mathematics, and by de Morgan, Manuel Johnson, and Charles Pritchard. He began his acquaintance with the heavens with a small telescope, but afterwards built a wooden observatory to house an equatorially mounted clock-driven instrument with object-glass of $5\frac{1}{2}$ inches aperture, which he used until he was 87 years of age, and he was wont to say, towards the end of his life, that he had followed Saturn nearly twice round its orbit. In his early married life he lived in South London, in the suburbs of Peckham and Camberwell, where he had for his comparatively near neighbour and friend, James Buckingham, the owner of a rather famous telescope with an object-glass of 21 inches' aperture, and Mr. Gibbs used to tell how Buckingham once called him out of bed at 1 o'clock in the morning to come to his observatory to look at Saturn: Gibbs went, and was rewarded by a view of Saturn, such, he said, as he never had before or after, the "seeing" being abnormally good. He went with the British Astronomical Association Expedition to Norway to see the total Solar Eclipse of 1896; to India in 1898; and to Ovar in Portugal in 1900 for a similar purpose. Mr. Gibbs was for many years a very regular attendant at the meetings of the Society until the advance of years brought small bodily ailments, which made it necessary for him to spend the winter months in a more genial climate than that of England. He often acted as Auditor of the Society's accounts, for which his acquaintance with finance made him specially adapted, and it pleased him to be asked to do this duty again a few years ago when he was the oldest Fellow of the Society. Mr. Gibbs had considerable artistic as well as scientific taste, and was an expert judge of pictures and a keen lover of music.

He married, in 1860, Elizabeth Nutting, who died in 1899, and had six daughters and three sons, all of whom, except one son, survive him.

He was elected a Fellow of the Society on 1857 January 9.

H. P. H.

Raymond Hill Godfrey, who died on November 5 last at the age of 66, was the eldest son of John R. Godfrey of Surbiton. He was at school at Westminster in the years 1871 to 1876, being elected to the foundation in 1874, and on leaving went to Ceylon, where he was engaged for some years in the coffee-planting industry. On his return to England about 1890 he became a member of the London Stock Exchange, and followed that avocation successfully until his death. He was always keenly interested in astronomy, and was a Fellow of the Royal Geographical Society.

He married Kate, the youngest daughter of Vice-Admiral Sir George Nares, K.C.B., F.R.S., the well-known explorer, who survives him, with two sons and two daughters.

He was elected a Fellow of the Society on 1893 April 14.

John Laver was born at Lara, near Geelong, on 1863 June 7, but while he was quite young his family moved to Kyneton, where they were well known and much respected. He was educated at the State School, and at the age of 18 entered upon his long connection with the timber trade of Melbourne. He was engaged first at Messrs. Oldfield & Lindley's timber-yard at Carlton, and, after holding the position of manager for two other firms, he became the Melbourne representative for Messrs. Davis & Felron, Ltd., one of the largest timber-importing firms in the Commonwealth.

For a number of years he was Secretary of the Timber Merchants' Association of Victoria, and was regarded as the greatest timber expert in the State. He was also an active member of the Microscopical Society of Melbourne, where he delivered several lectures on timber, illustrated by lantern slides, for which the specimens were cut and mounted by himself. He was working on the classification and nomenclature of timbers by microscopical examination at the time of his death. He was also a member of the Royal Society of Victoria, the Field Naturalists' Club, the Australian Forests League, and, in earlier years, the Historical Society of Victoria. His interest in astronomy began when he was 12 years of age.

He died suddenly on 1925 February 13, leaving a widow and two children.

He was elected a Fellow of the Society on 1924 February 8.

Frederick Clare Lees was born at Ashton-under-Lyne on 1871 August 15, and was the son of William Lees, one of the partners in Messrs. Gartside & Co., Ltd., a firm engaged in the manufacture of cotton goods and dyeing. His maternal grandfather, William Clare of Leeds, was a doctor of high reputation—a pioneer in his day,—so it is possible Lees inherited some of his scientific ability. His interest in science began in early life, and much of his spare time was spent in the laboratory of the Leys School, Cambridge. Following his natural bent, at the end of his school days, he took a Science and Chemistry course at Owens College, Manchester, where he qualified for the post of manager of the chemistry side and laboratories of his father's business. Here, as a result of some experiments with aniline dyes, he developed blood-poisoning of such severity that he was obliged to give up the work, and possibly this was the beginning of his study of astronomy, for it was while he was recovering from his illness that he bought a lens and fitted it to a wooden tube mounted on a tall stand ; but his subsequent interest in the science was theoretical rather than practical.

About this time Lees decided to take Holy Orders, and entered, at a comparatively late age, Hertford College, Oxford. At the end of his University career he took a First Class in Natural Science.

He spent the next few years of his life in several curacies, and in 1907 he joined the staff of the Missions to Seamen as Organising Secretary. In 1916 he became assistant superintendent, and, finally, in 1921 he was appointed superintendent, which office he held until his death.

Fond of travel he set out, in 1900, on a trip to Iceland, with the

object of exploring the interior of the island. The results of this expedition were submitted in a paper read before the Royal Geographical Society, for which he was rewarded with a Fellowship. Subsequently he travelled extensively in different parts of the world, and visited Australia, New Zealand, the South Sea Islands, and West Indies.

Lees' interest in science was many sided; he became a member of the Quekett Microscopical Club, and latterly wireless found in him a great enthusiast, and he was the first President of the Sutton Wireless Society.

Throughout his life he was a man of great industry and concentration on any subject he took up, and even during his times of leisure he was always occupied. He possessed almost a professional knowledge of mechanical engineering, and during the war much of his spare time was spent in making munitions. Before starting on the practical side of any work he would completely master the theoretical details and sometimes spent months in reading up his subject. He was a lover of nature in all her various forms, and his calling in life enabled him to indulge his passion for the sea; and even here it was a very practical interest, and the writer remembers hearing of his experiences aboard a North Sea fishing-smack. For some time he owned a small yacht.

To many he was apparently reserved; but those who pierced below the surface found in him an affectionate nature, a great lover of his work, and a loyal friend.

He married, in 1905, Ella Margery Davies of Swansea, by whom he had twin daughters.

He was elected a Fellow of the Society in 1918 November 8, and was a member of the British Astronomical Association, being at the time of his death Honorary Secretary of the latter. A. M. N.

Henry Curwen Lord was born at Cincinnati on 1866 April 17. He was a student at the Ohio State University for three years, after which he went to the University of Wisconsin. He graduated from that university in 1889. While a student there he was an assistant in the Washburn Observatory.

After his graduation he was for a short time engaged in electrical work, and in the year 1891 went to the Ohio State University as assistant in Mathematics and Astronomy. In 1894 he was made Assistant Professor of Astronomy and Mathematics, and in 1895 Associate Professor of Astronomy and Director of the Emerson M'Millin Observatory, it being in that year that the observatory was erected and equipped. In 1900 he was promoted to the rank of Professor.

Professor Lord's principal work in astronomical research consisted in the measurements of radial velocities, and this work led to the publication of a number of papers in the *Astrophysical Journal*, the principal one being in vol. **21**, 297. He observed the total solar eclipse of May 1900, and obtained successful photographs of the flash spectrum. The results are published in the publications of the U.S. Naval Observatory, second series, vol. **4**, pt. 4. Later he became interested in lens design, and published several papers on that subject, among them being two papers on the "Illumination of the Field of a Photographic Objective"

in the *Monthly Notices* of the R.A.S., vol. 76, 197, and vol. 76, 636. Still later he made observations of double stars, and published results in the *Astronomical Journal*.

For the use of his students in Civil Engineering he published a text-book, now out of print, entitled *Elements of Geodetic Astronomy for Civil Engineers*.

He married in 1898 Edith Hudson of Middleport, Ohio.

Professor Lord died on 1925 September 15, his health having been failing for some years. He is survived by his wife and an only daughter.

He was elected a Fellow of the Society on 1897 June 11.

Reginald C. Nelson was born at Lincoln on 1850 December 2[illegible]. He became a solicitor and carried on his profession at Sunderland.

He married Annie Hanson, daughter of John Theodore Hoyle of Newcastle-on-Tyne, in 1878, and had two daughters. His death took place at Sunderland on 1925 February 11.

He was elected a Fellow on 1888 May 11.

Ole Theodor Olsen was born at Christiansand, Norway, on 1838 August 14. He went to sea at an early age, and learnt navigation on an English sailing ship trading with India. Although he never lost touch with Scandinavia, he became completely English in his sympathies. He had an extensive knowledge, gained from his own investigations, of the movements of fish in the North Sea, and he collected and collated deep-sea soundings, so that he was often able to settle disputes as to the depth of ocean beds. After his life at sea he settled down at Grimsby as a maker of nautical instruments and a publisher of books for fishermen. He received honours in several countries, including Norway, Sweden, and Japan.

His mental keenness was unabated almost to the end, although latterly he had suffered from physical disabilities attendant upon his advanced age. He died on 1925 January 16, leaving a widow, a son, and two daughters.

He was elected a Fellow of the Society on 1903 May 8.

Arthur Edwin Brisco Owen was the second child, and only son, of the Rev. Brisco Owen, B.D., formerly Fellow and Vice-Principal of Jesus College, Oxford, Rector of Remenham, near Henley-on-Thames, where his son was born in 1858. At Harrow he showed a decided scientific bent, and from thence he proceeded to Oriel College, Oxford, where he took a 3rd Class in Classical Moderations and a 3rd in the Final Honours School of Natural Science. He was ordained deacon at Lichfield in 1881 to the curacy of Prees, and priest a year later. After two years at Prees he went as assistant chaplain to Constantinople, moving thence in 1885 to Kadikeui, where he remained till 1889, when he returned to England and became domestic chaplain to the Bishop of Lichfield. Later he held livings at Rodington, Salop, Stone, Staffs, Cholderton near Salisbury, and Ufton Nervet near Reading. In the early days of his residence at Cholderton he had a small transit instrument, with which he made regular time determinations. Soon

after this he purchased from a friend at Constantinople a 6-inch clock-driven equatorial refractor by Grubb, complete with observatory and revolving dome, and all other necessaries, including a sidereal clock by the same maker. Owing to various causes there was a little delay in its erection, but when once set up he frequently used it and kept it in excellent order, moving it to Ufton Nervet a few months after going into residence there. At one time it was hoped that he would take up the regular observation of variable stars, but about this time his health became too broken for such work. He observed the total solar eclipse of 1900 May 28 at Cape Matifou.

In addition to his astronomical tastes he was a keen registrar of meteorological statistics, having thermometers, barometers, anemometers, sunshine recorders, and rain-gauges, with which he was most punctilious in daily observations, all of which were entered in due form and order.

He was an ardent freemason, and in 1919 he held the office of Assistant Grand Chaplain of England.

This account must not close without a brief word of warm appreciation of his engaging personality. Possessed of an incisive and emphatic manner of speaking, enhanced by a great fund of humour, he was a most interesting and fascinating conversationalist. In any company and at all times, especially at a dinner-party, he was a notable addition to the circle, and not seldom the heart and soul of it. He was an excellent *raconteur*, and is much missed by a wide circle of friends and neighbours. He was not married. He died on 1925 July 3.

He was elected a Fellow of the Society on 1906 January 12.

C. D. P. D.

John Adelbert Parkhurst was born in Dixon, Illinois, on 1861 September 24, the son of Sanford and Clara J. (Hubbard) Parkhurst. He was educated in the public schools of Marengo, Illinois, and at Wheaton College (Illinois). Thence he went to the newly-established Rose Polytechnic Institute at Terre Haute, Indiana, where he received the degree of B.Sc., two years later, in 1886. He remained for two additional years as an instructor in Mathematics. After his return to Marengo he maintained for a dozen years a very modest private observatory, giving his principal attention to variable stars. When the Yerkes Observatory was established in 1897, within thirty miles of his home, he became a frequent visitor, and in 1898 a Volunteer Research Assistant. In 1900 he was appointed an assistant, and remained on the staff of the Observatory for twenty-five years, ranking in the later years as Associate Professor of Practical Astronomy in the University of Chicago.

Before he became officially connected with the Yerkes Observatory Parkhurst published a large number of papers in *Popular Astronomy*, the *Astronomical Journal*, and the *Astronomische Nachrichten*. His first published work at Yerkes was in collaboration with Hale and Ellerman on "The Spectra of Stars of Secchi's Fourth Type." His chief publications were on photometry, and in 1906 the Carnegie Institution of Washington, which had contributed to his salary by special grants,

published a quarto volume of 192 pages entitled *Researches in Stellar Photometry during the years* 1894 *to* 1906 *made chiefly at the Yerkes Observatory*. A most important work is the *Yerkes Actinometry*, published in the *Astrophysical Journal* for October 1912. This gives Parkhurst's determinations of photographic and visual magnitudes, colour indices, and spectral classes of all stars down to magnitude 7·5 north of declination 73°. A co-operative undertaking by the Harvard, M'Cormick, Lick, and Yerkes Observatories determined the magnitudes of faint stars in thirty-six fields. Parkhurst naturally represented the Yerkes Observatory, and when the results were published in 1923 in the *Memoirs of the American Academy of Arts and Sciences* his fine photographs of the thirty-six fields were included. Professor Parkhurst collaborated with Father Hagen in the preparation of No. XII. of the appendix to his *Atlas Stellarum Variabilium*. An important memoir on the photographic magnitudes and colour indices of 1500 stars in twenty-four Kapteyn areas remained unfinished at his death, but all the observations had been made and the reductions were in hand. It is pleasant to know that this work will eventually be printed.

Parkhurst went on three eclipse expeditions—to the American eclipses of 1918, 1923, and 1925, but it was only on the last occasion that he found a clear sky. At Ithaca, New York, on the morning of 1925 January 24, with the temperature below zero, he successfully measured the total brightness of the corona. He was taken suddenly ill with cerebral hemorrhage on February 27, and died two days later.

In boyhood Parkhurst suffered much from ill health, and he never acquired a robust frame. Yet by excellent discipline of mind and body he was able to work steadily to the end of his life, even although he did much night work of an exhausting nature. He left behind him upwards of a hundred published papers. Nor do these by any means cover the whole of his contributions to Astronomy. Most of the students of Astronomy who went to the Yerkes Observatory studied under him, and there must be many of the younger astronomers in America who learnt the use of astronomical instruments from him. He was a man of a quiet, retiring nature, and many will feel the loss of a real friend by his death. He is survived by his widow, Anna Greenleaf Parkhurst, whom he married in 1888.

He was elected a Fellow of the Society on 1905 April 14.

William Peck was born at Castle-Douglas, in Galloway, in 1862. Shortly after his birth his parents removed to Edinburgh, where his whole subsequent life was spent. In early boyhood his interest was turned to astronomy, and his aptitude for mechanics found expression in the construction of his own small telescopes. With the aid of these and of his own celestial charts his pioneer work in astronomy was done. In 1883, at the age of 21, he commenced his popular lectures on astronomy, which latterly became a real feature in the intellectual life of Edinburgh.

Peck did not proceed to a University career, and this fact most likely debarred him from the preferment which would probably have come to him as a matter of course. In his early twenties he was

appointed to direct a small private observatory at Murrayfield, in the western suburbs of Edinburgh, and while still a young man he was elected a Fellow of the Royal Society of Edinburgh, being nominated by the then Duke of Argyll, the well-known Victorian statesman. In 1886 he published *The Constellations and How to Find Them*, a useful guide for the beginner in observational astronomy.

When, in 1889, Piazzi Smyth retired from the post of Astronomer Royal for Scotland, the Government decided to build a new Royal Observatory on Blackford Hill, in the southern outskirts of the city. The old Observatory buildings were transferred to Edinburgh Town Council, and a new post was created—that of Astronomer to the City of Edinburgh. To this post and to the directorate of the City Observatory Peck was appointed, and in 1896 he entered on his new duties.

Peck's early astronomical work was mainly in the nature of star-charting. *A Handbook and Atlas of Astronomy*, which he published in 1890, contained a number of good charts for the amateur observer. More ambitious was his next venture—*The Observer's Atlas of the Heavens*, issued in 1898. In this work, one of the best of its kind, 9000 stars are mapped. Some years later he commenced a still more elaborate piece of work, in conjunction with Mr. T. W. Backhouse of Sunderland. This was a star-catalogue and atlas of the stars visible to the naked eye—9892 in number. For this catalogue Peck consulted all available authorities, and reduced all magnitudes to a standard scale. The charts were constructed under his supervision by his brother-in-law and assistant, Mr. George Pearson. In Peck's own words: "The maps are 30 inches square, and embrace an angular diameter of 110 degrees of the star-sphere on a scale which is equal to that of a globe 21 inches in diameter. They have been constructed on the gnomonic projection so as to be of use for meteor observers, and to enable the paths of meteors to be readily determined and investigated." Owing to lack of funds these large maps were never published.

In 1905 Peck observed the total solar eclipse in Spain. Some time later he visited Egypt to study the Pyramids at first hand. This subject ever appealed to him, and formed the subject of several lectures. Outside of astronomy he did much work in engineering, for which he had a very strong bent. He was knighted in 1917.

After the death of his wife, in 1921, Sir William Peck's health gradually failed. Late in 1923 he was stricken with mortal illness, and was for fourteen months an invalid. During this period the work of the Observatory was carried on by his assistants, Mr. J. M. Field and Mr. George Pearson. Sir William Peck died at his house in Inverleith Row, Edinburgh, on 1925 March 8, and was interred in Warriston Cemetery.

He was elected a Fellow of the Society on 1885 March 13. H. M.

Sir William Petersen, who was born in 1856 May, received his education at Roskilde and Copenhagen, and subsequently gained a prominent position in the shipping world. He was founder of the London American Maritime Shipping Co., and of the Royal and Uraneum Passenger Lines to Canada and the United States, was a

Director of the Thompson Steam Shipping Co., and chairman of Petersen & Co., Ltd., shipowners. He was also an honorary Commander in the R.N.R.

Sir William Petersen will be remembered in connection with the provisional agreement with the Canadian Minister of Trade and Finance for a subsidised service of ships in the Transatlantic trade, and for the part he took in the discussions on Canadian freight rates.

In 1889 he married Flora M'Kay, daughter of Mr. George Sinclair of Aberdeen, by whom he had one son and three daughters. His son was killed in action near Ypres in 1914, and his wife died in 1918. He was created a K.B.E. in 1920.

Sir William Petersen wrote a good deal on shipping and kindred topics, and was interested in astronomy, though, apparently, without taking any active part in astronomical work.

His death occurred on 1925 June 12. He was elected a Fellow of the Society on 1913 February 14.

Sir David Lionel Goldsmid-Stern-Salomons, Baronet, was born on 1851 June 28. He was the only son of Mr. Philip Salomons of Brighton, and Emma, daughter of Sir Jacob Montefiore, of Sydney, N.S.W. Both of his parents died while he was quite young, and he was brought up by his uncle, Sir David Salomons, M.P., to whose baronetcy he succeeded in 1873. In the same year he gained second-class honours in the Cambridge Natural Science Tripos. He took up electrical engineering, and was a pioneer in lighting by electric incandescent lamps, taking out several patents for his inventions. For many years he served on the council of the Institution of Electrical Engineers, and held the offices of treasurer and vice-president of that institution. He was also one of the founders and a vice-president of the Royal Automobile Club, and served as a member of the jury for the French Government at the Paris Exhibition of 1900. His interests were very wide, and included astronomy, photography, aviation, and clocks and watches. He wrote extensively on electrical matters, and published a valuable monograph on Bréguet (1747–1823), the great French watchmaker and founder of the celebrated firm of that name. In this work and the supplement to it are included a large number of photographs of Bréguet watches, which Sir David had collected—perhaps the largest and most varied collection of its kind.

In 1874 he was called to the bar by the Middle Temple. He also undertook various public duties, serving at various times as mayor of Tunbridge Wells, as a magistrate and deputy lieutenant of Kent, and as High Sheriff in 1881.

In 1882 he married Laura Julia, daughter of the late Baron Hermann de Stern, by whom he had three daughters and a son. The latter was drowned when on active service in 1915.

Sir David does not appear to have taken any part in practical astronomy, but he was a generous contributor to the Society's Special Fund initiated by the late Col. Grove Hills.

He died on 1925 April 19 in a nursing home, after an operation.

He was elected a Fellow of the Society on 1876 April 12.

Charles Bousfield Shaw was born at Hackney in 1847 June. He practised as a barrister-at-law for some years, but was obliged to abandon his practice owing to pressure of other activities, the chief of which was his occupation for fifty-seven years of the post of treasurer and secretary to the Royal Agricultural Benevolent Institution. He was a keen and active member of the Liberal party. His life-long interest in astronomy dated from his early intimacy with Colonel A. R. Clarke, R.E., F.R.S. He was a profound French scholar, and had a wide knowledge of French and English literature. He married in 1878 Eleanor Fanny, eldest daughter of Louis des Auges, who predeceased him. Mr. Shaw died at his London residence on 1925 December 13, and leaves two sons and one daughter.

He was elected a Fellow of the Society on 1921 February 11.

Walter Robert Stokes, the son of the Rev. Edward Stokes, a Wesleyan minister, was born at Barton-on-Humber on 1853 February 4. He lived for some time in Finsbury Park, North London, and was a company director interested in the piano and motor trades. He was during the war the president of the federation of cane and willow workers.

Mr. Stokes made a considerable study of astronomy, and delivered a large number of popular lectures on the subject. He died on 1925 August 4 from heart failure whilst bathing at Palm Bay, Margate.

He was elected a Fellow of the Society on 1919 February 14.

Proceedings of Observatories.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.
(*Director, Sir Frank Dyson, Astronomer Royal.*)

The 250th anniversary of the foundation of the Observatory was celebrated in July. Their Majesties the King and Queen graciously paid a visit to the Observatory on July 26. In commemoration of his visit His Majesty has kindly presented a signed portrait of himself which has been hung in the Octagon Room. By a happy coincidence the Meeting of the International Astronomical Union was at Cambridge this year, so that we were honoured by the visit of many distinguished foreign astronomers on this occasion. In the evening a reception was given by the President and Council of the Royal Society. On July 27 a number of guests were entertained at an official luncheon given by H.M. Government, at which the First Lord of the Admiralty took the chair.

Transit-Circle.—The number of transits observed during the year is 10,607, including 139 of the Sun and 100 of the Moon. The observation of the stars of $8^{m}\cdot0$ or brighter between Declination $+32°$ and $+64°$, begun in 1922, is about half completed. The reduction of the observations is well in hand, corrections to mean place being applied to all observations as far as 1925 August. The ledgers of clock and azimuth stars are completed to the end of 1924, and of all stars, reduced to epoch 1925·0, as far as 1923 September. A fresh investigation of the division errors of the transit-circle was commenced in November, and is still in progress.

Altazimuth.—The observation of transits across the prime vertical of stars in Boss's Preliminary General Catalogue has been continued. 2917 transits have been observed on 60 nights. It is hoped to complete the programme this year.

Cookson Floating Zenith Telescope.—The number of plates taken for variation of latitude is 242. They are well distributed through the year. The measurement is in hand, and probably will be completed by April.

Equatorials.—Six disappearances and two reappearances of stars occulted by the Moon were observed by one or more observers. Comet 1925 *k* (Peltier-Wilk) was observed on 3 nights and Comet 1925 *j* (van Biesbroeck) on 1 night.

28-inch Refractor.—During the year 526 observations of 359 double stars were made. Arranged according to separation they are :—

under $0''\cdot5$	41	observations.
$0''\cdot5-1''\cdot0$	135	,,
$1''\cdot0-2''\cdot0$	167	,,
over $2''\cdot0$	183	,,

A catalogue of the stars which have had three observations, similar to the one in the volume for 1920, will be published in the volume for 1925.

On Sunday nights and on other nights when the instrument is not in use for double star observations, the telescope is employed by Dr. Steavenson, for the observation of novæ and variable stars, which are too faint for smaller instruments.

Thompson Equatorial.—During the year 893 plates have been taken for parallax with the 26-inch refractor, and 965 have been measured (42 being re-measures). The results from the beginning of parallax observations to the end of 1924 were published during the year, and the parallaxes of 32 stars determined since this volume had gone to press were published in the *Monthly Notices* for 1925 November.

The measures of the plates taken for effective wave-lengths have been collected and put in form for publication. They cover the part of the sky from Dec. 80° to the North Pole.

With the 30-inch reflector used as a Cassegrain with a prism mounted outside the central hole, photographs of spectra have been taken for determination of the colour intensity in different parts of the spectrum. A coarse grating is mounted at the end of the tube to give a small dispersion in the direction perpendicular to that given by the prism for the purpose of determining the intensity scale at different parts of the spectrum. 35 plates of spectra of stars and 34 of the spectra of an arc or lamp placed on the Octagon Room roof have been taken. A few preliminary measures have been made, of which a brief account was given in the *Monthly Notices* for 1925 November.

Astrographic Equatorial.—The determination of the proper motions of stars in the Greenwich Astrographic Zones has been continued. During the year 80 fields were photographed through the glass, 22 in Zone 67°, 54 in Zone 69°, and 4 in Zone 71°. The measurement of Zone 67° was completed during the year and from 0^h-3^h in Zone 69°. In addition, 5 photographs of the Pleiades were taken for Professor Hertzsprung and 2 photographs of Wolf's Nova.

Photoheliographs.—Photographs of the Sun were obtained on 258 days at Greenwich and 330 days at the Cape. On 9 days photographs were not taken at either Observatory, but on 6 of these days photographs have been supplied from Kodaikánal. During the year a discussion has been made of the measures of position of the long-lived spots from the beginning of the Greenwich record to the end of the last cycle in 1923. A brief account is given in the *Monthly Notices* for 1925 April and a more detailed one in the Greenwich volume for 1925.

The mean daily spotted area, corrected for foreshortening, is approximately 800 millionths of the Sun's hemisphere, as compared with 276 millionths in 1924.

Clocks and Time-Service.—The clock, Shortt No. 3, obtained from the Synchronome Company, has been used as Standard Sidereal Clock during the year, and has proved extremely satisfactory. Time-signals have been sent regularly to the G.P.O. and to the British Broadcasting Company. The Greenwich signal is issued by wireless telephony from the company's stations at $10^h\ 30^m$, $13^h\ 0^m$, $16^h\ 0^m$, and $22^h\ 0^m$.

The wireless time-signals from Paris, Nauen, and Bordeaux have been received regularly, and those from Annapolis on 176 days.

Printing.—The Greenwich volume for 1923 is distributed and also a volume of Measures of Stellar Parallax. The volume for 1924 is printed but not bound. All arrears of printing occasioned by the war have now been overtaken.

Eclipse of the Sun.—Colonel Stratton and Mr. Barton spent a good deal of time at the Observatory during the autumn making preparations with Mr. Davidson for the Eclipse of the Sun in Sumatra on 1926 January 14. The instruments and other equipment were collected, tested, and packed at the Observatory. The whole, weighing 4 tons and packed in 40 cases, left the Observatory on November 2.

Miscellaneous.—Dr. Jackson has given considerable attention to the reduction of Hornsby's observations. This work is described in the report of the Radcliffe Observatory.

Mr. G. Merton has worked regularly at the Observatory throughout the year. He has continued his work on the determination of orbits (*M.N.*, 1925 June), and hopes to publish shortly a determination of the orbit of the Comet Grigg (1902, II), and show its identity with Comet Skjellerup (1922, I). During absence of regular observers he has assisted in observations with the 26-inch Equatorial.

Dr. K. Lundmark of Upsala worked at the Observatory during the summer months. During part of the time he and Mr. Melotte were engaged in an examination of the Franklin-Adams plates and they have drawn up a complete descriptive list of the vacant areas or regions of very low star-density in the sky. Dr. Asklöf of Upsala at the same time took a part in the observatory work on stellar parallax.

In the autumn two Russian astronomers, Dr. Beljaieff and Dr. Dnieprovsky, were engaged on the determination of the longitude Pulkovo-Greenwich. Their instruments, Repsold reversible transits with axis view and self-registering micrometers, were mounted in the transit pavilion. Happily these observers were favoured by the weather, and obtained a good number of full nights of observation.

Royal Observatory, Edinburgh.

Close attention has been given to the determination of time, both with the transit-circle and by the daily comparison on the micro-chronograph of the four principal clocks, Riefler No. 258, Shortt No. 0, Shortt No. 4, and Leroy No. 1230.

With the Cooke 6-inch photo-visual telescope with objective prism, the catalogue of stars down to about 3rd magnitude is under reobservation with a view to confirming the previous results as to the effective temperature of these stars. The stellar spectra are reproduced with the Koch microphotometer.

The laboratory work on the density of photographic images has been continued.

The solar spectroscope has been used as before to obtain plates for the determination of the solar rotation.

The measures of the magnitude of stars in the Perth Astrographic Plates have been continued. No further progress has been made in the publication of these measures.

The installation for the observing and recording of wireless time-signals has on the whole worked satisfactorily.

The seismological and meteorological observations have been carried on.

Mr. M. R. Madwar has been working at the Observatory throughout the year, and Dr. Gorakh Prasad was here during the first months of the year, both as research students.

Royal Observatory, Cape of Good Hope.
(*Director, Mr. H. Spencer Jones, H.M. Astronomer.*)

Reversible Transit-Circle.—The observations, commenced in 1918, of a list of stars selected from Boss's *Preliminary General Catalogue* were concluded in March. The new programme of observation includes all stars south of −30° Dec. and brighter than 7·5 magnitude, together with the zodiacal stars contained in the *Cape Catalogue* for 1900. Observations of the Sun, Mercury, and Venus were resumed in April. The observations during the year comprise :—

Observations of Right Ascension :—	
Meridian transits	8713
Determinations of collimation	114
,, ,, level	632
,, ,, azimuth	114
Observations of meridian marks	1194
Observations of Zenith Distances :—	
Determinations of zenith distances	8323
,, ,, runs	338
,, ,, nadir	559
,, ,, flexure	35

These include observations of the Sun on 117 days, of Venus on 68 days, and of Mercury on 44 days.

Current reductions are well advanced.

Old Transit-Circle.—A travelling wire micrometer for this instrument was constructed during the year in the Observatory workshop. Determinations of clock errors are now secured regularly with this instrument for comparison with the clock errors derived from the observations with the reversible transit-circle. Observations were secured on 54 nights, commencing September 22. Up to the present there is no evidence of a fluctuating systematic discordance between the two instruments.

Heliometer.—Observations of the major planets at their oppositions have been continued. The following observations were secured :—

Opposition of Neptune	48	obs.	in	distance	on	6 nights.
,, ,, Saturn	36	,,	,,	,,	,,	6 ,,
,, ,, Jupiter	24	,,	,,	,,	,,	4 ,,
,, ,, Uranus	46	,,	,,	,,	,,	6 ,,

The observations secured at the Opposition of Mars in 1924 have been discussed and a summary communicated to the Society. The evidence of a systematic source of error, arising from the use of screens, was discovered, the effect of which is to displace the apparent disc of the planet *towards* the zenith as the result of the chromatic dispersion of the atmosphere. The low value of the solar parallax resulting from heliometer observations of Mars is thereby accounted for.

The positions of Mars derived from the series of observations in 1924 were used in conjunction with the heliometer observations at previous oppositions to derive orbital elements of Mars. The observations point to a smaller mass for Venus than that adopted by Newcomb. The results have been communicated to the Society.

Victoria Telescope and Astrophysical Laboratory.—The telescope was in use on 184 nights during the year in conjunction with the four-prism spectrograph and short camera. An endeavour has been made to complete as far as possible the current radial velocity programme, in view of the approaching commencement of a programme of stellar parallax determinations. 213 star spectra were secured for radial velocity determinations and 276 plates were measured for this purpose.

Since the discovery, on May 25, of a bright nova in the constellation Pictor, a continuous series of spectra of the nova was secured, in so far as weather permitted, for studying the changes in its spectrum. 109 spectra were obtained up to the end of the year. The nova has proved to be unique in many respects, and in its later stages it has not followed the usual course of development. It now shows remarkable affinity with the well-known nova, η Argus, whose spectrum contains many strong lines of unknown origin, represented in the spectrum of Nova Pictoris by wide bright bands.

The results of the radial velocity determinations and a discussion of the spectral changes of Nova Pictoris are in course of preparation for publication in the *Cape Annals.*

The Astrographic Telescope.—The following plates have been taken with this instrument :—

Cape Astrographic Zones ($-41°$ to $-47°$)	384	plates	with	1528	exposures.		
Comet Reid (1925*b*) . . .	43	,,	,,	73	,,		
Comet Tempel II (1925*d*) . . .	10	,,	,,	13	,,		
Comet Ensor (1925*l*) . . .	9	,,	,,	15	,,		
Comet Brooks region . . .	1	,,	,,	1	,,		
Nubecula major	2	,,	,,	2	,,		
South Polar region	5	,,	,,	15	,,		
Nova Pictoris	10	,,	,,	110	,,		

The fields of the Cape Astrographic Zones were photographed through the glass with a view to determining proper motions by comparison with the plates of the original series and to deriving improved values of the magnitudes. 215 plates were measured for proper motion.

From the photographs of Mars secured at the opposition of 1924, the value $8''{\cdot}809 \pm 0''{\cdot}005$ for the solar parallax was derived. The results have been communicated to the Society.

The manuscript is ready for press of a catalogue giving the photo-

graphic magnitudes of the 20,843 stars contained in the Cape Zone Catalogue for 1900. The magnitudes have been derived by comparison with 24 standard areas, each of which was compared with the South Polar area, which in turn was standardised by means of a grating. An introduction to the volume, containing a discussion of the material, is in course of preparation. A comparison with the magnitudes of stars in the Harvard standard regions in the zone $-45°$ reveals the same differences in scale between Harvard and the Cape as between Harvard and Mount Wilson. Apart from a slight difference in zero point, the Cape magnitude scale is therefore in close agreement with the Mount Wilson scale. Counts of stars of different magnitudes confirm this agreement. A discussion of the colour-indices, derived by using the visual magnitudes of the revised Harvard Photometry, has revealed that the distribution is not a normal error distribution, but that, for each spectral type, there is a preferential grouping around certain equally spaced values. The same phenomenon has been found to exist in the *c*/T values of the Potsdam photometry and of Hertzsprung's mean colour equivalents.

Photoheliograph.—683 photographs of the Sun to supplement the Greenwich series were secured on 330 days. Visual observations for zero were made weekly.

All original negatives taken up to September 28 and duplicates to November 23 have been forwarded to Greenwich.

Occultations.—Twenty-five occultations of stars by the Moon were observed, viz. :—

Disappearance at dark limb	13
Reappearance „ „	12

Wireless Time-Signals.—The wireless receiving apparatus was overhauled and remodelled during the year.

From November last the regular reception of the Bordeaux time-signals has been resumed.

Since the 6th February, time-signals, emanating from the Observatory, have been sent out, usually three times daily, by the local Broadcasting Company.

Publications.—Cape Independent Day Numbers for 1926 and 1927 have been issued.

The *Cape Astrographic Zones*, vol. **8** ($-48°$), has been passed through the press and issued.

The following parts of the *Cape Annals* have been passed through the press and issued :—

Vol. **8**, part 7.—Occultations of Stars by the Moon, observed in the years 1907 to 1922.

Vol. **8**, part 8.—Determination of the Elements of the Moon's orbit, the Parallactic Inequality, and the Moon's Semidiameter from Occultations, 1880–1922.

Vol. **13**, part 1.—Proper motions of Stars contained in the *Cape Fundamental Catalogue* of 1846 Stars, for the Equinox 1900.

Miscellaneous.—The time-signal and meteorological services have been maintained as usual. A thermograph and a hygrograph, provided by the Meteorological Department of the Union Government, have been installed.

Personal.—Mr. Cox retired in July after forty-two years' service at the Observatory. By his retirement the Observatory has lost a very faithful and zealous worker. Mr. Cheeseman was promoted to be assistant, and placed in charge of the Time Department and of the Transit-Circles. Mr. Jackson was promoted to the higher grade of junior assistants. The vacancy in the junior assistants has not yet been filled.

H.M. Astronomer attended the meeting of the International Astronomical Union at Cambridge.

Armagh Observatory.
(*Director, Rev. W. F. A. Ellison, M.A.*)

All the principal instruments are now in working order, with the exception of the 7-inch transit-circle. The old 15-inch metal Cassegrain in the East Tower was dismounted last year, and a 6-inch refractor (the object-glass made in the Observatory workshops by the Director) mounted on the same equatorial, which, with its circles and clock, is still in excellent order, notwithstanding its 85 years' service.

Sixty-nine transits of stars were observed with the $3\frac{3}{4}$-inch transit instrument, and 145 measures of 68 double stars made with the 10-inch Grubb equatorial. Most of the results have been published in *Monthly Notices*. Some faint pairs were observed with the 18-inch Calver equatorial; but, owing to the want of illuminating apparatus on the Calver telescope, no measures were made.

Several excellent photographs of the lunar eclipse on February 8 were taken in the principal focus of the 18-inch mirror.

The solar eclipse of January 24 was observed from first contact till near the greatest phase, when clouds interfered with further observation.

The 6-inch equatorial was used for this, for occultations of stars by the Moon, for observations of sun-spots, exhibition of objects to visitors, and other general purposes for which its handy size fits it.

Observations of the occultation of Aldebaran, on February 2, and of several stars in the Hyades on the same night, were sent by request to Dr. R. T. A. Innes at Johannesburg.

Climatological observations were carried on according to the programme of the Air Ministry. The lowest shade temperature was 17°·1 on December 25. Highest, 77°·0 on June 11. Lowest grass minimum, 11°·1 on December 25. Total rainfall for the year, 30·39 inches. Greatest fall in one day, 1·04 inches on July 26. Wettest month, May, 4·62 inches. Driest, June, 1·09 inches.

Cambridge Observatory.
(*Director, Professor A. S. Eddington, F.R.S.*)

A photoelectric photometer has been purchased, and at the end of the year arrangements were being made for mounting it on the Sheepshanks Equatorial. It is thought that the *coudé* form of telescope may have advantages for this form of work, since the photometer remains in the same position when the telescope is moved.

Further progress has been made with the photographic determinations of small proper motions; 8 more regions have been completely reduced, bringing the total to 25. The material accumulated is now about sufficient to justify a general discussion of the data for the purpose of determining the apices and velocities of star-streaming among the distant stars.

The number of photographs taken with the Sheepshanks Equatorial is 154, including 76 of Kapteyn areas, 59 taken "through the glass" for the proper motion investigations, 13 of ϕ Persei in connection with its suspected light variation, and 6 experimental photographs of double stars.

Solar Physics Observatory, Cambridge University.
(*Director, Professor H. F. Newall, F.R.S.*)

Spectroheliograph.—Photographs of the sun's disc in K_{232} light were obtained on 105 days (previous year, 100); and photographs of the prominences at the sun's limb were obtained on 81 days (previous year, 85).

The general solar activity has increased very rapidly during the year, and many large disturbances have been recorded. Fewer outbursts have occurred in the higher latitudes beyond 30° N. and 30° S., the greater number having been in the zones 20° to 25° N. and 20° to 25° S.

For the year 1924 October 1 to 1925 September 30, the director of the Kodaikanal Observatory has sent 343 spectroheliograms showing the sun's disc in K_{232} light.

In continuation of his investigations of the distribution of bright masses of calcium flocculi, detailed measurements of the growth of individual masses are being made by Mr. Butler.

Study of Sun-spot Records and Prominences.—The tabulation of outbursts of sun-spots in the four 11-year cycles, 1879–1923, has been completed by the director with the assistance of Mrs. Beech, and the evidences of existence of related sequences of outbursts are being examined.

The list of prominences observed at Kodaikánal in 1924, and received in MS. through the kindness of Dr. Royds, has been plotted by Mr. Moss graphically in continuation of the previous observations. The distribution, motions, and recurrences of sequences of prominences are being investigated.

Stellar Spectra.—The study of stellar spectra in the region of wave-

lengths longer than that of H_α has been undertaken by Mr. Carroll with a grating spectrograph attached to the Newall Telescope of aperture 25 inches. Exposure times are necessarily long, but promising results have been obtained by the use of hypersensitised plates.

A detailed examination has been made by Mr. Baxandall of the absorption lines in the spectra of stars of types G0, K0, K2, K5, and M*a*. The wave-lengths, intensities, and probable origins of the lines in the Cambridge series of spectra of the sun (G0), α Bootis (K0), α Arietis (K2), α Tauri (K5), and α Orionis (M*a*) have been determined. The results are being compared with a view to investigating the nature of the changes that occur in the spectra along this portion of the stellar sequence.

A revision of the origins assigned by Rowland to lines in his Preliminary Tables of Solar Wave-lengths was begun by Mr. Baxandall in 1916 by reference to many published and unpublished records of spectra which had accumulated since Rowland published his tables in 1887. The revision has been recently resumed, and is being completed for the region $\lambda\lambda$ 3900–5900 in connection with the proposed publication of a co-operative revision of Rowland's tables by the International Astronomical Union.

Spectra of Ionised Atoms of Heavier Elements.—The work begun by Mr. Carroll in Professor Millikan's laboratory at the California Institute of Technology and in the laboratory of the Mount Wilson Observatory, has been completed and published in the *Philosophical Transactions of the Royal Society* (vol. 225A, 357–420). The spectra (spark *in vacuo*) of gallium, indium, thallium, germanium, lead, and mercury had been photographed by Mr. Carroll in California in 1924. Wave-lengths have been measured between λ700 A and λ5000 A, and the discussion of the resulting data has recently been completed. Classification in series has been investigated, and a scheme complete with term values has been developed for the spectra of : HgII, GaIII, InIII, ThIII, GeIV, PbIV. Satisfactory agreement with calculations based on Bohr's theories of atomic structure has been found.

Dunsink Observatory.
(*Acting Director, Mr. Charles Martin.*)

The time-service to Dublin has been continued as in previous years. The meridian circle has been used only for time determination, a comparison being made daily between Paris and Dunsink mean time. The Paris time-signals are of great value to the Observatory, as the rate of the sidereal clock cannot be depended on for any length of time.

The Observatory has been used mainly for teaching purposes, students being welcome in the daytime for instrumental instruction and any clear evening for observational work.

Durham University Observatory.
(Director, Mr. Harold Thomson, M.Sc.)

The weather during the past year again proved unfavourable, observations having been obtained on only 93 nights. The work on long-period variable stars has been continued. 656 determinations of magnitude have been made, including a few observations of Wolf's Nova. Twenty-nine maxima and eight minima of variable stars have been observed. Mr. Sargent has also carried out his usual observations on the surfaces of the planets. Eleven occultations of stars by the moon were recorded and the lunar eclipse of February was observed. Observations were made of comets Shajn, Orkisz, Van Biesbroeck, and Peltier-Wilk.

Rain fell on 204 days, the amount for the year being 26·1 inches. 1326 hours of sunshine were recorded during the year; 72 days were entirely sunless.

Norman Lockyer Observatory, Salcombe Hill, Sidmouth.
(Director, Major William J. S. Lockyer, M.A., Ph.D.)

The routine of photographing the spectra of stars with the 12-inch McClean prismatic camera for the determination of spectroscopic parallaxes has been continued, and, in addition, a series of spectra of *o* Ceti has been taken during the recent period of maximum brightness (1925, November and December). The 9-inch Kensington instrument has been used on bright line stars of special interest, among which may be mentioned ϕ Persei and *o* Ceti. During the period September 9 to the end of the year this instrument was used by the Director on every fine night in order to secure a series of spectra of ϕ Persei throughout a complete cycle of its variations. During this period measurable photographs were secured on 75 nights out of a possible 114, the total number of negatives taken of this star being 105. These photographs are being continued up to the end of the cycle, which occurs about the middle of January 1926.

Spectroscopic parallaxes of 525 stars of types F0 to M and 100 of type B have been published during the year (*Memoirs of R.A.S.*, **64**, and *Monthly Notices*, **85**, 439), and work is being continued on the latter stars to investigate other methods of treatment.

A paper on the spectrum variations of ϕ Persei has been communicated to the Society (*Monthly Notices*, **85**, 580), and a further paper, discussing the latest results from the series of photographs mentioned above, is in preparation.

Photometric as well as spectroscopic observations have been made of *o* Ceti, and a paper is in preparation describing the results obtained at recent maxima.

The Observatory is open to the public on Wednesday afternoons, and the number of visitors who attended during 1925 was 222.

The Director attended the meeting of the International Astronomical Union at Cambridge in July, being present officially as a member of the commissions on spectral classification and stellar parallax.

The annual general meeting of the Norman Lockyer Observatory Corporation was held on June 11.

Radcliffe Observatory, Oxford.
(*Director, Mr. H. Knox-Shaw, Radcliffe Observer.*)

The programme of work with the 24-inch refractor on the proper motions of stars in Kapteyn's Selected Areas has been continued. During the year 47 plates on these areas have been taken, of which 36 have been passed for measurement. Although better than in 1924, the observing conditions were not good, as during the rather long periods of high pressure the sky was generally veiled with haze, or there was low-lying fog.

Sixteen plates have been measured, and the reduction of six areas has been finished during the year. The limiting photographic magnitude remains of the same order as before, the mean value being very closely 15th magnitude, and the probable error of a centennial P.M. in one co-ordinate (mean of two plates) is, as before, slightly larger than $\pm 0''{\cdot}5$.

A bifilar micrometer has been obtained for the measuring machine, and, after the errors of its screw had been determined, it was brought into use in May. Its introduction has much simplified the plate measurement.

Dr. J. Jackson, of the Royal Observatory, Greenwich, and the Director have undertaken the reduction of the meridian observations made by Hornsby, the first Radcliffe Observer, between 1774 and 1803. Full details of the material that awaits discussion are given in *M.N.*, **60**, 265. A start has been made on this work, the heavy computation involved being done by computers, whose salaries are being defrayed by a grant from the Royal Society. About one hundred of the stars most frequently observed by Hornsby have been selected as standard stars, and the observations made of these stars and of the Sun in 1780 and 1781 have been reduced. The standard of accuracy of the observations seems quite satisfactory. The probable errors in R.A. and Declination of a single observation of the Sun (two limbs in R.A. and one in Dec.) are in 1780 $\pm 0^{s}{\cdot}060$ and $\pm 1''{\cdot}6$, and of a standard star $\pm 0^{s}{\cdot}046$ and $\pm 1''{\cdot}1$, which may be considered reasonably small.

Radcliffe Observations, **54**, part 4 (Meteorological), was printed and distributed as usual. Two additional computers, whose appointment was sanctioned in order to accelerate the reduction of the proper motion plates, commenced work in February. In other respects there has been no change in the staff.

University Observatory, Oxford.
(*Director, Professor H. H. Turner, F.R.S.*)

Volume vii (zone $+58°$) of the Vatican Astrographic Catalogue has been distributed, and volume viii (zone $+57°$) is now fully printed, and a few copies have been already distributed.

A great deal of work has been done by Mr. Bellamy during the year on the Vatican ledgers, which are approaching completion.

The valuable work of Dr. Fotheringham has been recognised by his appointment as Reader in Ancient Astronomy and Chronology in April

last. In accepting the new appointment he vacated the position of regular assistant at the University Observatory, but has accepted that of honorary assistant. The Observatory will thus happily retain the services of a scholar who can, and does, give his earnest attention to the questions submitted by other scholars who have not his knowledge of astronomy. During the term of his assistantship it has become increasingly clear that such questions are by no means rare, and the consideration of them by a competent authority a real need: that the University Observatory should thus remain able to meet this need would seem to be in good accord with Oxford traditions.

Responses to enquirers are, however, only a portion of Dr. Fotheringham's work. The researches into Babylonian chronology, mentioned in the last report, were continued, and extended by the consideration of the cases where the months were known to have had thirty days, as shown by contracts signed on the 30th day. The whole of the evidence was found to support Dr. Fotheringham's suggested chronology, and a summary of it was given in his Inaugural Lecture as Reader on May 15. It will be given in full detail in book form.

Suggestions for (somewhat overdue) repairs to a portion of the Observatory buildings, and an extension of the library with provision for the seismological work, were approved by the Board of Visitors in May last, and have been under favourable consideration by the University, but their execution has been delayed by the prior need for building activity in several other directions.

The seismological reductions are complete to the end of 1922 October, and are printed to the end of 1922 April. In the last report the printing was up to 1920 September, so that six months' arrears have been caught up during the year. This satisfactory result is again largely due to the help received from Dr. J. E. Crombie and the Department of Scientific and Industrial Research, who have between them provided the salary of Mr. J. S. Hughes: and to the care and assiduity of Miss Bellamy in arranging the mass of detailed information which flows in continually.

The Director has spent much time on the investigation of a magnetic periodicity of 9·2 years, originally suggested by seismological work: and in an analysis of the sun-spot numbers, to see whether it could be traced therein. The answer was in the negative, but an interesting confirmation of the alternation of sun-spot cycles back to 1750 was an incidental outcome of the work.

Imperial College, South Kensington.
(Assistant-Professor H. Dingle.)

The Observatory has been used only for the instruction of students, the facilities for which have been much increased by the re-installation of the 5-inch equatorial.

Research work in the laboratory has dealt mainly with the successive spectra of the lighter elements, which are of importance in connection with the physical conditions in the atmospheres of the hotter stars. Professor Fowler has communicated to the Royal Society an analysis

of the spectrum of O II, and is now engaged in further investigations of the carbon and other oxygen spectra. Assistant-Professor Dingle has continued the study of the spectra of fluorine, and Mr. Freeman, those of nitrogen. The spectrum of ionised neon has also been under investigation by Mr. Ganesan. Miss Saltmarsh has published an account of the spectra of doubly- and trebly-ionised phosphorus (*Proc. Roy. Soc.*, A, **108**, 332, 1925), and Mr. Beals has traced a number of regularities in the arc spectrum of palladium with the aid of original investigations of the Zeeman effects (*Proc. Roy. Soc.*, A, **109**, 369, 1925). By the same method he has just completed and presented to the Royal Society, a study of the term-relationships in the copper-arc spectrum. The known series of copper have been extended by Mr. Pinch by means of a special method of producing the flame-arc spectrum.

Stonyhurst College Observatory.
(Director, Rev. E. D. O'Connor, S.J.)

It is with deep regret we record the death of our late Director, Father Cortie, on 1925 May 16. Father J. P. Rowland carried on the work of Director until the appointment of the new Director, which did not take place till December.

The Observatory staff was further considerably handicapped by sickness, with the result that very little more than routine work was done during the year.

The meteorological, magnetic, and seismological observations have been carried on as usual, and the results forwarded to the official centres. Father Rowland attended the meeting of the International Astronomical Union at Cambridge, and was nominated a member of the Solar Physics Commission. He has also been elected a member of the Seismological Committee of the British Association.

Observations of the solar surface were made on 254 days. The drawings number 251, and of these 208 are complete, showing all spots and faculæ. Of the remaining 43, ten are complete for spots. There were 29 recorded spotless days, 16 of which occurred in January. A marked increase in solar activity started in May, and this became very pronounced in November and December. The mean daily disc area of the spots (in units 1/5000 of the visible disc) was 3·51, as compared with 1·36 in 1924, and 0·37 in 1923. The mean daily disc area of the spots for November was 7·45, whilst for December it was 15·10.

As was to be expected, the increasing solar activity has been accompanied by a corresponding increase in magnetic disturbance. There are indications of a number of instances of sequences of disturbances at approximately 27 day intervals, but owing to the depletion of staff already referred to, it has not yet been found possible to make a detailed examination of these. It is hoped, however, that this investigation will shortly be continued.

The grating spectograph has not been in use during the year, owing to the lack of a mirror for the heliostat ; the 10-inch mirror formerly on loan from the Permanent Eclipse Committee, and the 8-inch mirror

subsequently substituted for it, both having been recalled for use on eclipse expeditions. The 4-inch 20-foot lens, lent to us by the Royal Irish Academy, is also away for service with the Eclipse Expedition to Sumatra.

University of London, University College Observatory.
(Director, Prof. L. N. G. Filon, F.R.S.)

The routine work of the Observatory, which is largely of an instructional character, has been carried on as in previous years. Spectrographs of integrated sunlight were not taken after June 18, when the cœlostat and mirrors, for the loan of which we have to thank the Astronomer Royal, were packed for return to the Royal Observatory, Greenwich, for use in the eclipse observations. The presence in the Sun's spectrum of the bands of nitrogen was the subject of an investigation by Mr. H. S. Aiyar, who obtained a negative result. Other bands and "many line" spectra were also investigated without a positive result.

The use of a floating mirror for determinations of the Zenith with the transit-circle was investigated by Mr. H. C. Woods.

Miss E. Williamson made a number of measurements of radial velocities from contact plates of Yerkes' spectrograms, and obtained good agreement with published values. In view of the interest attaching to peculiarities of instruments and measuring machines, as well as to the probable errors of different observers, the Observatory would welcome the co-operation of other observatories in the measurement of some typical star plates and spectrograms, both solar and stellar.

Dominion Observatory, Ottawa, Canada.
(Director, R. Meldrum Stewart.)

Meridian Work and Time-Service.—Observations with the meridian circle were continued on the previous programme. About 3500 star observations were obtained and 105 observations of the sun, besides observations of the moon and planets. If there is any difference between clock corrections from morning and evening observations, it is too small to be apparent without a closer examination than it has so far received.

The time-service has been maintained as in previous years without substantial alterations. The total number of clocks and dials controlled from the Observatory is about 600. 211 clocks and watches were cleaned and repaired for the Observatory and other Government Departments.

Wireless time-signals from Annapolis, Lafayette, and Nauen have been received regularly by the method of coincidences by extinction, and occasionally by automatic registration. Additional time-signals were occasionally observed during the summer for longitude determinations.

Solar Physics.—About 370 photographs were made of the spectrum of the sun, and comparisons, each consisting of 9 spectrum strips; these include a particularly homogeneous set of the solar rotation in June at λ 6500. Remeasures were made of the rotation observations of 1909 and 1910 at λ 4250, λ 4500, and λ 5600, with precautions to free the measures from certain errors introduced by oil in the nut of the measuring machine.

The 15-inch Equatorial.—Radial velocity work has been continued on bright cepheids, pseudo-cepheids, and stars of the ϕ Persei type. 653 spectrograms were secured. A study of ν Eridani showed a large variation of the amplitude of the short-period radial velocity oscillation; the suspected period of this variation is about eight days. An investigation was made of radial velocities from lines originating at different levels in ζ Geminorum and η Aquilæ. The variation of ionization in variables of the δ Cephei and ζ Geminorum types was investigated by comparison of the two titanium lines 4534·139 and 4534·953.

Photographic Photometry.—The study of photographic light curves of cepheid variables has been continued, 394 plates having been obtained. Co-operation has been arranged with a number of observatories in different longitudes which will all follow the same programme, so as to obtain light curves as nearly continuous as possible. Co-operation has also been arranged with several observatories for measurement of the magnitudes of comparison stars in the fields being photographed. These magnitudes are to be determined from those of the standards given in *H.C.O.*, vol. 85, No. 1. 160 plates were obtained at Ottawa on this programme.

Seismology.—During the past year seismic activity was very pronounced. 369 earthquakes were recorded, of which 63 were particularly well marked, and were reported to the press. Mention may be made in particular of the Alaskan earthquake of February 23, the St. Lawrence series beginning February 28, the Montana shocks of June 27, and the destructive Santa Barbara earthquake of June 29. A detailed investigation was made of the St. Lawrence earthquake, and a report will shortly be published. A new seismograph station was installed at Ste. Anne de la Pocatiere near the centre of this disturbance.

Terrestrial Magnetism.—Observations for the three magnetic elements were made at 32 stations. 25 of these are located in the section east of longitude 70° and south of latitude 52°; the remaining 7 are along the Labrador coast, the most northerly being at Nain. Of the total, 26 are repeat stations for the determination of secular change.

Gravity.—20 new stations were occupied at points in western Canada where topographical maps for the isostatic reductions are available. 13 of these stations were in the prairie provinces, the remaining 7 being in the mountainous section of British Columbia.

Publications.—Six publications were issued during the year: vol. vii., Nos. 1 and 2; vol. viii., No. 7; and vol. ix., Nos. 1, 2, and 3.

The Dominion Astrophysical Observatory, Victoria, B.C.
(Director, J. S. Plaskett, F.R.S.)

The Staff.—The staff of the observatory consists of J. S. Plaskett, Director; W. E. Harper, Assistant Director; H. H. Plaskett, Research Astronomer; J. A. Pearce, Assistant Astronomer; S. N. Hill, Computer; Miss H. R. Keay, Secretary; T. T. Hutchison, Night Assistant. During the summer vacation Mr. W. H. Christie was employed again as Observing Assistant for five months and Mr. R. M. Petrie for two months.

Observing.—The weather was slightly less favourable for observing than usual, a total of 1643 spectra being obtained on 202 nights as compared with the average for seven years of 1653 on 206 nights. On 134 nights, five or more plates were obtained per night with a total of 1487, while on 68 nights less than five were obtained per night with a total of 168. On 10 nights, in addition, although the dome was opened and exposure started, no usable spectra were obtained. In continuance of the policy of allowing visitors to observe with the 72-inch telescope, two hours on each Saturday evening have been given to visitors, with upwards of 200 attending during the height of the tourist season.

Researches.—The observing time of the director has been occupied chiefly in obtaining spectra of B-type stars in continuation of the work commenced in 1924 of investigating all the B0 to B5 stars brighter than 7·5 visual magnitude and north of $-10°$. Considerable time has been spent in determining the orbits of two massive B-type binaries and one A-type binary with double-lined spectra enabling the masses and approximate dimensions and parallax to be deduced. Further observations of the eclipsing variable 21 Cassiopeiæ were obtained, and additional solutions made with the result of removing the previously found difference of 17 minutes between spectroscopic and photometric phase and indicating probably that similar and greater differences in phase found in several other eclipsing variables are due to observational errors with their resultant distortion of the least-squares orbits. Some 18 spectra were obtained of the binary υ Sagittarii which Ludendorff, on the basis of Wilson's orbit and Miss Maury's remarks on the spectrum, calculated as having a mass of 260 times the sun. The measurement of these plates, mostly obtained at times of maximum and minimum velocity, shows no indication whatever of a doubled spectrum, and there is no basis for Ludendorff's calculated mass. The spectrum is variable and very peculiar, and the apparently doubled lines observed by Miss Maury appear to be due to complex structure of emission and absorption of hydrogen. The director was absent about four months, and during that time attended the meeting of the International Astronomical Union at Cambridge.

Mr. Harper has continued the observation of A-type stars, principally of those with directly determined parallaxes, to form the basis for the determination of the spectroscopic parallaxes of the A-stars. As time is required to collect sufficient observational material before the empirical curves can be obtained, sufficient spectra have been obtained to complete the orbits of eight spectroscopic binaries in four of which

both component spectra appeared, and these orbits have all been corrected by least-squares and prepared for publication. A discussion of the A-type spectra has been begun and some new pairs of lines suitable for determining the absolute magnitude have been found.

Mr. H. H. Plaskett was occupied during the earlier part of the year in an attempt to extend and confirm the interferometer observations of the Orion Nebula mentioned in last year's report. All the earlier plates with a new one were carefully remeasured on the Hartmann microphotometer, yielding, as before, the suspected fringes. Certain inconsistencies in the resulting wave-lengths led to suspicion of the reality of the fringes, and it was finally established that the observed " fringes " were spurious and due to symmetrically placed discontinuities in the light of the nebula modified in a curious way by passage through the spectroscope and etalon. A complete theoretical investigation of all known and possible sources of error in the wedge method of spectrophotometry has been completed, and the method of procedure so revised that all known systematic errors have been eliminated or avoided. This work led to securing a complete new series of spectra of Vega and the sun, free from errors inherent in the earlier series, in order to obtain the absolute intensities of the absorption lines. It is hoped to publish soon the results of this investigation. In addition, a complete plan of observation to determine the colour temperature of the hotter stars with the greatest possible accuracy has been drawn up and some spectra have been secured.

Mr. J. A. Pearce has continued the observation and measurement of B-type spectra in collaboration with the director, and in addition has determined the orbits of two massive B-type binaries with double-lined spectra. One of these, Boss 46, H. D. 1337, which is of type O8–O9, had a spectroscopic orbit determined previously by Adams, while its light curve was obtained with a photo-electric photometer by Guthnick. The spectroscopic and photometric orbits could not be reconciled so that the new determination of the spectroscopic elements by Mr. Pearce, with a new discussion of the light curves, enabled the complete dimensions of the system to be obtained. It is the second most massive system known with masses 35 and 32 times the sun, densities 0·01 and 0·003 with the components nearly in contact. These results, which are of importance in mass-luminosity and other relations, are now being thoroughly discussed and prepared for publication.

Mr. W. H. Christie obtained and measured spectra for radial velocity of 48 stars, and also obtained and measured additional spectra of the short-period binary 12 Lacertæ. These results are now in the press and will appear shortly.

Publications.—The *Publications of the Dominion Astrophysical Observatory*, vol. 3, Nos. 5 to 8 inclusive, have been distributed; Nos. 9 and 10 are in the press; while, in addition, a number of papers by members of the staff have appeared in astronomical periodicals.

Helwan Observatory, Ministry of Public Works, Egypt.
(Director, Mr. P. A. Curry.)

The Reynolds reflector was not used during the year owing to lack of staff. It is hoped in the coming year to recommence work with it.

The rhythmic W/T signals transmitted from Lyons and Bordeaux were regularly observed throughout the year. Transits were taken on 93 nights. The Riefler and Synchronome Clocks performed well during the year.

The usual meteorological, magnetic, and seismological observations were made. The temperature coefficients of the Watson Magnetographs were re-determined in February.

Kodaikánal Observatory.
(Director, Dr. T. Royds.)

The Director was on leave till 1925 December 17, and Mr. A. A. Narayana Aiyar, Assistant, was in charge of the Observatory during the period. Owing to limited staff, the work of the Observatory during the year was confined to the usual routine, which was carried out on the same lines as in previous years.

The collection of prominence and H_α spectroheliograms from other observatories for days not represented in the Kodaikánal series was continued as a part of the programme of the International Astronomical Union. Since 1925 October, Mr. Evershed's Observatory at Ewhurst has been added to the list of institutions from which these photographs are obtained.

At the instance of Lord Rayleigh, the Observatory is taking part in his scheme of observations of the luminosity of the night sky. Messrs. A. A. Narayana Aiyar and P. R. Chidambara Aiyar are participating in this work, and the results of observations are periodically communicated to Lord Rayleigh.

Except during the last few months, the observing conditions were on the whole satisfactory. Photographs of the sun on a scale of 8 inches to the sun's diameter were obtained on 328 days, using the 6-inch visual achromatic object-glass and a green colour-screen. Monochromatic images of the sun's disc in K light were obtained on 327 days, prominence plates on 283 days, and H_α disc plates on 285 days.

The annual report for 1924 and bulletins, Nos. 75, 76, and 77, dealing with prominence observations during the second half of 1923 and the whole of 1924, were published and distributed during the year.

During his leave the Director visited the Meudon Observatory and attended the Cambridge Meeting of the International Astronomical Union.

Nizamiah Observatory, Hyderabad.
(*Director, Mr. T. P. Bhaskaran, M.A.*)

The routine work with the Astrographic Equatorial was continued on the same lines as in former years. Seventy-four photographs have been obtained with the instrument for various purposes; of these, twenty-four were exposed through the glass for direct comparison by superposition on earlier negatives, and nineteen plates were taken for photometric investigations. Much preliminary work has been done in connection with the measurement and reductions of the proper motion and photometry plates.

Vol. v. of the *Hyderabad Astrographic Catalogue* containing measures of plates in Zone −21° was distributed during the year. A start has been made with the printing of vol. vi. (Zone −22°) and twenty-four pages of proof have been read and passed for press. It is hoped that the volume will be completed by the end of 1926.

The Grubb 15-inch Telescope.—Regular observations of long period and irregular variables have been continued. Fifty-nine variables were under observation and 719 determinations of visual magnitude have been made to the end of the year.

The number of fine nights on the whole was considerably below the average and work was interrupted by continuous cloudy weather which prevailed from June to October.

Occultations.—Observations of nine disappearances and four reappearances of stars occulted by the moon, were made during the year.

Transit Instrument.—This telescope was in frequent use for determining clock corrections. A drum chronograph made by Cooke, Troughton, & Simms has been brought into use for recording observations with this instrument.

Seismology.—The Milne-Shaw seismograph installed in 1923 September, has been in continuous operation, and 92 earthquake shocks were recorded during 1925. The microseisms characteristic of the monsoon period appeared on the records for 19 days.

Meteorology.—A few simple meteorological instruments have been added to the equipment of the institution, and observations with these were commenced early in the year.

There have been no changes in the staff of the Observatory.

Union Observatory, Johannesburg.
(*Director, Dr. R. T. A. Innes, Union Astronomer.*)

During the year Mrs. S. Human retired and Mr. W. S. Finsen succeeded her. Professor E. Hertzsprung, who arrived in November 1923, left in May, and was succeeded by Dr. W. van den Bos (also seconded by the Leiden Observatory), who arrived in August.

26½-Inch Visual Refractor.—The object-glass arrived here in January and by April the observations were begun. It cannot yet be said that the object-glass is finally adjusted to its best working position, but during the last six months it has been in use every clear night, mainly,

if not entirely, for double-stars observations. This work is summarised as follows :—

887 measures of double stars
303 new double stars discovered.

The great majority of these stars thus measured are under 1″ in distance, and many are from 0″·18 to 0″·30. Naturally the telescope has been tested by looking at the most difficult known double stars in the northern sky, and in every case such stars have been duly seen—hence the expectation that if the object-glass could be somewhat improved, its useful field of work would be greatly enlarged.

Some interesting discoveries have naturally been made and will be reported in due course. At the moment it is worth recording that the chief star in the nucleus of the great looped nebula in the Large Magellanic Cloud is a close double star, and whilst sweeping a zone for new pairs, van den Bos and Finsen measured one which they could not identify in the C.P.D. Further search revealed that the "double star" thus measured was the planet Pallas. This recalled an observation made here some years ago that Eros was seen "double."

The micrometer by Repsold is most convenient to use : its screw value is about 9″. The great telescope is convenient to handle—it can be manipulated by one person, the observer—but when going over a zone for new double stars the presence of three persons is desirable. The most noticeable feature, to the observers here who were previously accustomed to much smaller apertures, is the power of the telescope in bringing out the colours of the stars. It would be ungracious not to mention our indebtedness to Sir Howard Grubb and his skilful staff.

Occultations of Stars.—A limited programme was undertaken. In all 68 occultations were observed, of which 5 were reappearances of ephemeris stars—all dark-edge phenomena. The simple and unweighted means of all for which star-places are available is :—

	Time Error.	Error of Moon's Mean Longitude.
	s	″
Disappearances	13·7 (55 obs.)	7·5
Reappearances	12·7 (5 ,,)	7·1
		7·4

The occultation results since the introduction of Brown's tables roughly grouped give—

	Time Error.		Error of Moon's Mean Longitude.	
	s		″	
1923·4	14·6		8·0	Includes observations
23·6	16·9		7·6	made elsewhere : see
23·9	13·6		7·5	U.O. Circ. No. 63.
24·1	14·9		8·2	See U.O. Circ. No. 64.
24·4	16·3	(well marked maximum)	9·0	
25·4	14·4		7·9	Unpublished.
25·6	13·1		7·2	
25·8	13·0		7·1	

It has to be remarked that the star-places available are in general 25 to 30 years or more old. A zodiacal catalogue of stars to the 9th magnitude is much wanted; and apart from its uses for occultations and furnishing comparison-stars for minor planets, its stellar statistical value, covering as it would a great circle of the sky, should be greater than similar data derived from small circle zones. In addition to our own reductions, a considerable number of occultations observed elsewhere during the lunation preceding and lunation following the total solar eclipse of January 1925 were reduced, and the results sent to Professor Brown and Dr. Comrie.

Time Service.—Throughout the year, the clock corrections have been obtained from the rhythmic signals emitted at 8^h U.T. by the wireless station at Bordeaux; the times of the first and the last beats, as signalled on the following day, have been used. Local Sidereal Time is obtained by adding $1^h\ 52^m\ 18^s{\cdot}0$ to the Greenwich Sidereal Time obtained from Bordeaux.

Variation of Latitude.—At Dr. Schlesinger's suggestion a curtailed programme of observation has been started.

Union Observatory Circulars.—During the year Circulars Nos. 62, 63, and 64 have been issued, and with them four maps of portions of the southern sky. The progress of the latter now stands as follows :—

Maps already issued	210
Maps in Government printer's hands . . .	14
Maps still to be made	332
Total	556

Circulars No. 65 (Transit of Mercury) and No. 66 (Physical Observations of Mars, etc.) are in the Government printer's hands. In No. 65 a discussion upon Newcomb's lines of all the transits of Mercury is given, and the conclusion arrived at is that the Earth's rotation is variable, by jumps. This conclusion is confirmed by the time-departures of the Moon, the Sun, and the eclipses of Jupiter's Satellites I and II, the correspondence being exact within the limits of error. A short note to this effect was published in the *A.N.*, No. 5382, whilst the main paper was sent to Cambridge in time for the meeting of the Astronomical Union.

Comets.—The following comets have been observed :—

Comet Reid 1925*b*	on 53 nights.
Comet Tempel (ii.) 1925*d*	,, 22 ,,
Comet Ensor 1925*l*	,, 13 ,,

The observations have been fully reduced and will appear in a forthcoming circular.

Orbits of 1925*b* and 1925*l* have been computed by Mr. H. E. Wood, who is also trying Merton's and other modifications of Olber's method.

Minor Planets.—During the year 103 photographic positions of 41 minor planets have been obtained with the Franklin-Adams Star-

Camera. The places have been sent to the Astronomisches Rechen-Institut.

The Secular Perturbations of Pallas by Jupiter were computed by a modification of Gauss's method, and the results sent to Dr. de Sitter.

Work in Hand.—The usual routine is: Minor planets and comets south of the Sun; eclipses of JI and JII; the measurement of double stars and a zone durchmusterung search for new ones to magnitude 9·0; occultations of stars near 1st quarter; latitude-variation.

The new catalogue of double stars is on the eve of publication, and it will be issued on the loose-leaf system. It will be composed upon a special typewriter now on order, and reproduced by a mimeograph machine. As the printed pages require revision, they will be replaced by others brought up-to date. The additions to every page of the MS. catalogue due to the use of the 26½-inch render some such arrangement compulsory, otherwise the catalogue would practically be out-of-date on the date of issue.

A new orbit computation of α Centauri is in progress. It takes into account the secular changes of all the elements (save e), and is based on 4-year-interval normal places. The theoretical basis is a slight modification of Thiele's method (*A.N.*, No. 2488), and requires for its convenient and general use tables of

$$X = r/a \quad \cos v$$
$$Y = r/a \quad \sin v.$$

These tables are now being computed to five decimal places for each degree of M (mean anomaly), and each 0·01 of the eccentricity from 0·00 to 1·00. These tables when completed will have other uses, especially when Cowell's powerful method comes into its own.

Adelaide Observatory.
(*Director, Mr. G. F. Dodwell, Government Astronomer.*)

The usual work, as described in previous reports, was continued.

Rhythmic wireless time-signals from Bordeaux were received regularly from the end of April to the end of the year. Signals from Saigon were also received, but regular reception was prevented by interference apparently due to A.C. machines in the vicinity of the Observatory. A special series of short-wave time-signals (71·5 metres) from Annapolis was heard with great distinctness in September (local time 8·35 p.m.).

A Milne-Shaw seismograph was received from England to supplement the records taken with the existing Milne seismograph. It was installed in the same room, and records commenced on September 10.

Following on the visit of Mr. W. J. Rooney from the Carnegie Institution Magnetic Department, experiments were made with apparatus designed to measure earth resistivity at depths varying from a few feet to about half a mile below the earth's surface. The instrument will be used in conjunction with magnetometer and dip circle in magnetic field work.

Melbourne Observatory.
(*Director, Dr. J. M. Baldwin, Government Astronomer.*)

The new clock, Shortt No. 5, was received in Melbourne in October, and the Free Pendulum has been mounted in an underground cellar which had been prepared for its reception by waterproofing the floor and some distance up the walls, bricking up the window, and putting double doors in place of the single one. Provision will also be made for keeping the temperature constant. The adjustment and regulation of the clock is now in progress.

The computation of the proper motions of the stars in the *Fifth Melbourne Catalogue* has been completed, data being available for 1837 of the 2603 stars comprising the catalogue.

The third volume of the *Astrographic Catalogue* (plates with centres along $-69°$ and $-70°$) is ready for the printer, and money is provided on the estimates both for the publication of this and of the *Fifth Melbourne Catalogue*. A considerable amount of work in the preparation of the manuscript of later volumes has been done, but the amount of revision required has proved to be unexpectedly large.

Plates for 34 additional regions of the Astrographic Chart have been taken, and also plates of Comet Reid were obtained on six evenings. The positions will be published shortly. Observations of long-period variables have been made as in previous years, and all the results have been published among those of the American A.V.S.O. in *Popular Astronomy*. The magnitude of Nova Pictoris has also been observed whenever opportunity offered.

The magnetic work at Toolangi has been carried on as usual. In April both houses were roofed with zinc. In July the temperature coefficients of the H and Z variometers were determined. The coefficient of Z was inconveniently large, and in consequence the temperature compensator for Z was reinstalled in November, and the coefficient reduced to a small value. The magnetograms for 1924 have been measured and the results are nearly ready for publication.

The electric wiring of the Observatory has been altered and a common battery installed for all circuits where such a course was possible. The changes in the 8-inch transit-circle have been proceeded with, but owing to many unavoidable interruptions progress has been much slower than was anticipated.

Sydney Observatory.
(*Director, W. E. Cooke, Government Astronomer.*)

Astrographic Telescope.—The new driving clock continued to give trouble and has caused much loss of time. The manipulation of the dome shutters has always required heavy physical work, and several outside engineers have been invited to construct some form of counterpoising, but at last this was definitely pronounced impracticable. Whereupon the observer and mechanician designed and carried out a simple scheme which is completely successful.

Owing to these interruptions the output of photographs has been less

than usual, but more than sufficient to keep pace with the measuring staff.

In the winter portions of the sky large sections are completed, and work has been recommenced upon the chart plates.

Publications.—Vols. i. and ii. of the *Astrographic Catalogue* were completed and distributed during the year. Vols. vii. and viii. have been passed through the press and will shortly be distributed. Vols. xxv. and xxvi. are completed and waiting to go to the printer.

Just at present, however, it is impracticable to obtain authority for any except routine work.

Transit-Circle.—A catalogue of all "intermediate" stars between 30° and 51° S has been completed, and a manuscript copy has been made and forwarded to Dr. Schlesinger.

The preparation of this catalogue, which seemed to be urgently required, and which has occupied us for two years, interrupted the zone observations of reference stars for the Sydney astrographic zone. At present these are completely observed, reduced, catalogued, and ready for the printer between declinations 51° and 55°.

For several reasons work on the zone 55°–57° has not yet been recommenced. Advantage has been taken of this forced delay to commence an experimental investigation of the best methods of time determination for longitude work.

Wireless Time-Signals.—The proposed co-ordination of Pacific stations by means of vernier signals transmitted from Honolulu has not been successful, owing to their inaudibility at Washington. They were well received in Sydney.

An experiment with short-waves (71·5 metres) conducted by the Naval Radio Station, Bellevue (N.K.F.), and issued from Washington, was very successful. The signals were clearly audible at Sydney. A request has been made for similar signals to be transmitted from Honolulu.

New Clock.—A "free pendulum" and slave clock has just been completed for the Sydney Observatory by the Synchronome Co., and is expected to arrive early in 1926.

Dominion Observatory, Wellington, New Zealand.
(*Director, Dr. C. E. Adams, Government Astronomer.*)

1924–25.

Astronomical Equipment.—A new transit micrometer for use with the Observatory No. 1 transit instrument was obtained from Messrs. Cooke, Troughton, & Simms, London, and fitted to the instrument. Improvements were also made in No. 2 transit instrument by fitting two setting-circles on the tube: this provides for the rapid reversal of the transit instrument and improves the accuracy of the observations. A machine for measuring photographs taken by the photographic telescopes has been lent to this Observatory by the Melbourne Observatory.

Astronomical Observations.—Observations of the meridian transits of the stars and of the sun have been made for the purpose of controlling

the time service. During the year the sun was observed 171 times, and 236 observations were made of stars.

Time Service.—The time service has been maintained and regular signals have been sent out. The following mean-time signals were received at the Observatory: From Honolulu, 271 signals; from Malabar, Java, 168; from Kavite, 72; from Bordeaux, 2. Scientific time-signals were also received as follows: Bordeaux, 41; Saigon, 102; Honolulu, 213; Nauen, 11.

Sun-spots.—Observations of sun-spots are made on every available occasion, and the reports are published in the *Monthly Notices of the New Zealand Astronomical Society.* The number of observations made during the calendar year 1924 was 217, when sun-spots were recorded on 146 days. Forty-nine separate groups of sun-spots were observed.

Transit of Mercury.—The beginning of the transit on 1924 May 7 was not observed, as the sun was not visible until 11h. 5m. From then until sunset the sun was visible through passing clouds. The sky was clear at meridian transit, and observations were made. A report of the observations is published in the *M.N.*, **84**, 775, 1924.

The work in seismology has increased very considerably since the new Milne-Shaw seismograph has been running; and, in addition to the technical reports on the earthquakes, contact photographic prints are made of all important records, and are sent regularly to Professor H. H. Turner, President of the Seismology Section of the International Geodetic and Geophysical Union.

Mr. Scriven Bolton's Observatory at Bramley, near Leeds.

Further progress has been made in determining the periods of new variable stars in the Pleiades, the Hyades, and in the region R.A. $1^h\ 15^m$ to $2^h\ 38^m$, N. Dec. 37° to 55°. The 6-inch Dallmeyer lens, of 30 inches focal length, has been used as hitherto. The plates invariably used are Ilford Iso-Zenith, speed H. and D. 700, size $6\frac{1}{2}$ by $8\frac{1}{2}$ inches. They have a maximum sensitiveness at 4600 to 4800 and a secondary maximum at about 5600.

Of the last-named region above referred to, which has as its centre γ Andromedæ, 134 photographs were obtained during the interval 1922 November 1 to 1925 March 12. The observations have proved sufficiently numerous to enable one to deduce some reasonably accurate periods, and the work was discontinued on the latter date. About forty variables have been found on the negatives. Light curves have been made of 29. Eight of these denote an irregular type variable, while the remaining 21 are characteristic of Pickering's Class IV., being short-period regular variables, identical with the Cepheid type. The shortest period is 14·1 days and the longest 75·0. The majority of the curves are regular, though showing sudden minor fluctuations. Three types of curve are manifested: (1) The simple regular rise and fall; (2) Ditto, but with a secondary maximum not always midway between the primary maxima; (3) a halt at mean magnitude. On either side of this stationary line both rise and fall are very abrupt.

The Pleiades.—Work was begun on 1924 August 14, and continued on nearly every clear night except during the months of May, June, and July. 121 stars down to the 12th magnitude within a radius of 1° from Alcyone have been examined. Of these, 80 are found to belong to the short-period regular Cepheid class. The remaining 21 exhibit tolerably constant magnitudes. According to Lick Observatory Bulletin No. 333, 45 of these variables are actual members of the group, while the remaining 35 are background stars. It is yet too early to deal with the individual periods, but in passing it might be mentioned that the shortest period for 1924–5 works out at $16\frac{1}{2}$ days and the longest $49\frac{1}{2}$ days. Among these variables are included 5 of the 6 brightest stars of the cluster, as well as Pleione, and the background star SY Tauri, which latter is referred to below. Light curves of the 80 variables have been constructed. This list does not by any means exhaust the total number of variables existing in this region. It is intended later on to examine all the stars within a radius of 3° from Alcyone.

SY Tauri.—When compared with adjacent stars, the visual magnitude exceeds the photographic by approximately one magnitude, due evidently to the star's reddish colour. Short-period variability of between 30 and 40 days has been found. The curve for 1924–5 is regular, and shows a secondary maximum. The observations are being continued in order to determine the period more precisely.

A new Algolid.—This star is located about $1\frac{1}{2}$° to the right of Y Andromedæ. Duration of phase $4^h\ 50^m$. The mean period for 1924–5 is $32^h\ 34^m\ 34^s \pm 2$ seconds. The star is white, or perhaps bluish-white. At "stationary" magnitude its brightness undergoes a relatively slow variation. It has a photographic magnitude of 10·0 ; at minima 12·9 : thus exhibiting a drop of nearly three magnitudes.

The Hyades.—The plates of the Hyades for 1924–5 are under examination, and the results will be given later. On the negatives of the Pleiades and surrounding region for March 1925 the trail of Mars is depicted.

In this work I desire to express my warmest thanks to Dr. Robert Trumpler and Mr. Felix De Roy for valuable information and references, etc.

Wolsingham Observatory.
(Rev. T. E. Espin.)

The search for new double stars has been continued during the year, and the results presented to the Society.

Lee Observatory, Chorlton-cum-Hardy.
(Mr. A. A. Buss.)

The past year afforded 192 different observing dates, but the whole of December was lost owing to illness of the observer, which, in view of the particularly active state of the sun during that month, is much regretted.

During the first six months of the year under review the northern hemisphere still preponderated largely in general activity, and only during the second six months has the southern hemisphere shown decisive signs in this respect. Towards the end of the year it exhibited rapidly increasing activity, both as regards spots and prominences.

The Rowland grating spectroscope attached to the 5-inch Cooke equatorial was mostly used for the observation of disc and limb phenomena. Some notable instances of anomalous dispersion effects over spot-umbræ were recorded, also numerous splendid instances of the claw effect near spot-umbræ, almost invariably on the red side of H_ϵ. Further, a number of observations were again made which left no doubt as to the contour of prominences being frequently and very strongly affected by occulting gas-clouds between the observer and the bright prominence formation behind these clouds. The unique spectacle of a whole series of eruptions could be witnessed on September 13, from 10.30 a.m. till 3.30 p.m., between position angles 50° and 80°, a succession of paroxysms of the most violent order working up ultimately into a blast which, for very many degrees south of p.a. 80°, swept all prominences and chromospheric projections away and smoothed the sun's limb, besides showing other incidental phenomena. There can be no doubt whatever as to the actual transport of matter being involved. The observer hopes to be able to present to the Society a detailed account in the near future.

Mr. A. M. Newbegin's Observatory, Sutton, Surrey.

The usual routine work on the solar prominences has been carried out as far as possible, but in the first half of the year observations were very intermittent on account of extensive repairs to the dome and also because the observer was laid up for three months, during which only one recorded observation was made. Eighty-four observations yielded 818 prominences, and their distribution indicates a preponderance at the north and east limbs. Metallic outbursts were recorded on 25 occasions, 72 per cent. being in the northern hemisphere and 60 per cent. in the eastern, showing a striking eruptive activity in these regions as compared with the south and west limbs of the sun. Displacements of the H_ϵ line were seen on 15 occasions, 13 being to the violet: their distribution north and south was equal, but the east limb claimed by far the greater number. Dark absorption was again conspicuous on the few occasions on which it was observed. The new Littrow type spectroscope has been in regular use since September, and the preliminary results of the observation of sun-spots justify the hope that it will prove capable of the work for which it was designed.

Mr. B. M. Peek's Observatory, Boscombe, Hants.

With the 12¼-inch reflector photometric observations of three novæ and two variables of the U Geminorum type were continued. Nova Persei 1901 has been observed on 118 nights. Considerable improvement has been effected by substituting a prism for the silvered flat.

Physical observations of Mars were continued until May 2, principally to ascertain whether the south polar cap would completely disappear. Though it became excessively minute towards the end of January it never actually vanished.

Jupiter was observed as often as possible, but lack of sky-room so low in the south rendered systematic work impossible.

With the 5-inch refractor and the society's Cooke position micrometer measures were made of a few more double stars within 35° of the pole.

Nine occultations of stars by the moon were observed, of which the observations of seven have been reduced and the results published.

At the end of the year the instruments were dismantled and moved to Herne, Kent, where up to the time of writing only a few observations have been made with the 5-inch mounted as an alt-azimuth. The site for the new observatory has, however, been selected, and is in longitude $4^m\ 27^s.74$ E, latitude 51° 21′ 17″·8 N., altitude 47 feet.

On the re-erection of the Observatory the 5-inch refractor will be replaced by a 6-inch refractor by Zeiss.

The Rev. T. E. R. Phillips's Observatory, Headley, near Epsom, Surrey.

There was a marked improvement in the weather of 1925 as compared with that of the previous year, and observations were obtained on a large number of nights, several of which yielded very good seeing conditions.

The usual programme of work on the planets, double stars, and variable stars was continued.

Despite its great S. declination, much delicate detail was observed on the surface of Jupiter, and the times of about 350 transits of markings across the planet's central meridian were secured for longitude, together with some micrometer measures for latitude determinations. The Red Spot itself was definitely seen on a few occasions, but it is now very faint, and the hollow in which it lies became very shallow.

The most striking fact deduced from the Jupiter observations was that the rotation period of the S. Tropical Disturbance had become for the first time longer than that of the Red Spot.

The variable stars observed were some of those on the B.A.A. list, which are faint at minima. T Draconis was unusually faint from the latter part of June to the beginning of September, and V Camelopardalis was invisible during the greater part of the year.

The results of the double star measures have been communicated to the Society.

Some time was devoted during the earlier part of the year to experimental measures of bright double stars by an adaptation of the interferometer. So far as they go, the separations obtained seem to be generally somewhat larger than those given by the filar micrometer, but further work remains to be done in investigating possible sources of systematic error.

Dr. W. H. Steavenson's Observatory, West Norwood.

Observations were made on 144 nights, the majority of which fell in the second half of the year.

The 6-inch refractor has been used chiefly for photometric observations of faint novæ. In all, 236 observations were made of 11 of these objects. The results of similar work in 1924–5 have been communicated to the Society.

During the last five months of the year some work was begun on a few irregular and long-period variables, most of which have faint minima. 687 observations of 27 of these stars were made, and have been communicated to the Director of the Variable Star Section of the British Astronomical Association. The faintest of the novæ and variables have also been occasionally observed with the 28-inch refractor of the Royal Observatory, by kind permission of the Astronomer Royal.

A few observations of Mars were made with the 6-inch telescope in January and February, after which the apparent diameter of the planet became too small for useful results with this aperture.

The partial solar eclipse of January 24 and the partial lunar eclipse of February 8 were both observed, but under somewhat unfavourable conditions.

During the year measures were made of the positions of comets Schain-Comas Sola, Reid, Orkisz, Tempel, Van Biesbroeck, and Peltier-Wilk. The results were in each case communicated to the Royal Observatory as soon as the measures had been made.

Notes on some Points connected with the Recent Progress of Astronomy.

Discovery of Minor Planets in 1925.

Eighty-five planets were discovered in 1925, as follows :—

Month and Designation.	Day of Month.	Magnitude.	Discoverer.	Month and Designation.	Day of Month.	Magnitude.	Discoverer.	Month and Designation.	Day of Month.	Magnitude.	Discoverer.	Month and Designation.	Day of Month.	Magnitude.	Discoverer.
Jan.				Apr.				Sept.				Nov.			
AA	14	14·2	W	GC	1	13·8	R	RA	14	13·7	R	VA	11	16	W
AB	14	15	W	HA	22	13·6	R	RB	14	13·0	R	VB	11	15·0	W
AC	14	13·5	R	HB	22	13·5	R	RC	14	13·9	R	VC	15	13·7	R
BA	21	13·8	R	HC	23	13·4	R	RD	14	14	R	VD	15	12·0	D
BB	21	13·7	R	May				RE	14	16·5	W	VE	12	12·8	B1
BC	20	13·5	K	KA	19	13·8	R	RF	14	14·0	W	VF	15	13·8	J
BD	20	13·2	J	KB	20	14·5	W	RG	15	14·5	W	VG	15	13·6	B2
BE	26	13·7	B1	KC	24	14·5	W	RJ	15	14	R	WA	15	14·5	W
BF	18	14	K	KD	29	15·5	W	RK	9	13·7	S	WB	18	14·7	W
Feb.				June.				RL	9	13·1	S	WC	18	14	R
CA	15	13·5	A	LA	15	12·2	J	SA	15	13·2	R	WD	19	13·3	R
DA	16	13·8	B1	MA	22	13·0	S	SB	15	14·0	R	WE	20	..	V
DB	17	13·5	A	July.				SC	25	13·8	A	WF	20	..	V
DC	28	13·3	A	NA	15	12·2	A	SD	23	13·5	U	WG	17	13·1	B3
DD	26	13·4	K	OA	19	13·3	A	SE	24	13·4	S	WH	18	12·0	D
Mar.				OB	22	12·9	R	SF	24	13·3	S	WJ	23	13·6	B4
EA	4	14·0	B1	Aug.				Oct.				WK	23	12·5	B4
FA	22	13·6	R	PA	13	13·4	R	TA	9	13·7	R	Dec.			
FB	31	13·9	W	QA	16	13·4	S	TB	10	13·6	R	XA	6	13·6	R
FC	31	13·8	W	QB	16	12·7	S	TC	10	13·6	R	XB	6	15·0	W
FD	19	14	K	QD	21	13·0	S	TD	11	12·5	B1	XC	7	13·8	R
Apr.				QE	21	13·2	S	UA	21	12·9	J	XD	7	15	W
GA	1	13·8	R	QF	21	13·5	A	UB	24	13·7	A	XE	7	16·5	W
GB	1	13·5	R	QH	26	13·6	K								

The initials stand for : A=V. Albitzky, Simeis ; B1=S. Beljavsky, Simeis ; B2=V. Bervy, Moscow ; B3=E. Buchar, Algiers ; B4=E. Bugoslavsky, Moscow ; D=E. Delporte, Uccle ; J=B. Jekhowsky,

Algiers ; K=J. Kasansky, Moscow ; R=K. Reinmuth, Königstuhl, Heidelberg ; S=G. Shajn, Simeis ; U=Miss E. Uschakova, Moscow ; V=L. Volta, Pino Torinese ; W=M. Wolf, Königstuhl, Heidelberg.

I believe U is the first lady's name in the list of minor planet discoverers.

The new system of lettering, in which the first letter changes twice a month, was used for the first time in 1925. The year (or its last two digits) must now be prefixed in all cases, as the lettering begins afresh each year.

Several of the planets in the above list were discovered independently at two observatories : in such cases I give the earlier discovery, unless this is in the wrong month for the lettering (assigned from the later, but first published, detection). *Ast. Nach.* 5402 gives two additional planets discovered in 1924 by H. E. Wood, Johannesburg, on plates taken 1924 July 7 and 8. They are lettered 1924 *a*, 1924 *b*.

The following identities have been established : 323 *Brucia*=1923 NT (this is interesting as being the first of Professor M. Wolf's numerous planetary discoveries : it had been missing since 1891, the year of its discovery ; 1923 NT had been named *Potomac* before the identity was established ; this name now lapses). 383 *Janina*=1925 QC. 396 *Aeolia*=1925 RH (this planet had been missing since its discovery in 1894). 597 *Bandusia*=1924 SG. 699 *Hela*=1923 OZ. 706=1924 TN. 720 *Bohlinia* (=1911 MW)=1901 HA ; a re-examination of plates taken in 1894, 1899, 1904, 1906, 1914 has revealed images of the planet in each year. It belongs to the Koronis group with $n=723''\cdot3$. 748 *Simeisa*=1925 QG. 836 *Jole*=1903 LZ (this planet has been missing since its discovery in 1916).

The following planets, unnumbered at the date of the last Report, have received permanent numbers : 1025=1923 NX, 1026=1923 NY, 1027=Y.O. 11, 1028=1923 PG, 1029=1924 RK, 1030=1924 RQ, 1031 =1924 RR, 1032=1924 SA, 1033=1924 SM, 1034=1924 SS, 1035=1924 SW, 1036=1924 TD, 1037=1924 TF, 1038=1924 TK, 1039=1924 TL, 1040=1925 BD, 1041=1925 FA, 1042=1925 HA, 1043=1925 HB, 1044=1924 RO, 1045=1924 TR, 1046=1924 UA. 1046 was discovered by Professor G. van Biesbroeck at Yerkes 1924 Dec. 1, 25 days before Professor M. Wolf's discovery. It was followed till 1925 Mar. 29.

The following planets have been named : 720 *Bohlinia*, 753 *Tiflis*, 850 *Altona*, 895 *Helio*, 964 *Subamara*, 966 *Muschi*, 1029 *La Plata*, 1036 *Ganymed*.

Ganymed (Dr. W. Baade's interesting planet 1924 TD) was observed at Johannesburg till Mar. 17 last, and at Yerkes till April. G. Stracke gives the following elements in *Ast. Nach.* 5410.

Epoch 1924 December 31·5 G.M.T.

M	21° 16′ 58″·1	1925·0	φ 32° 38′ 21″·2
ω	130° 38′ 0″·3		n 814″·4452
Ω	216° 27′ 22″·3		log a 0·426096
i	26° 8′ 50″·0		Period 4ʸ·35656

1029 *La Plata* was observed by Professor J. Hartmann from 1924 Apr. 28 to July 28. Its eccentricity is small, 0·025 ; i is also small, 2°·5. Period 4·91 years.

Dr. G. Stracke notes that 1009 (1923 PE) can make very close approaches to Mars (see last Report but one for approximate elements) and may eventually give improved determinations of its mass. 1019 has a short period, 2·642 years, and a high inclination, 27° ; but its eccentricity is small, 0·07, so that it remains outside Mars' orbit.

The Trojan planets, *Achilles*, *Hector*, *Priamus*, *Nestor*, *Agamemnon*, were all observed in 1924 or 1925. 132 *Æthra* was observed at Bergedorf in 1925, this being the second opposition since its recovery. 887 *Alinda*, whose orbit resembles that of 1036 *Ganymed*, was in perihelion last year, and was well observed.

J. Kasansky found the brightness of 695 *Bella* variable (B.Z. 45).

In *Ast. Nach.* 5359 Miss J. M. Vinter Hansen investigates the motion of 24 *Themis* from 1919 to 1923, using the Copenhagen tables.

Ast. Nach. 5375 contains Dr. G. Witt's ephemeris for Eros about the time of the near approach in 1931 Jan. ; this is also given in *M.N.* **85**, 997. *Ast. Nach.* 5375 and 5403 contain lists of selected comparison stars by A. Kopff. Observatories are invited to co-operate in obtaining meridian observations of these stars.

In *Ast. Nach.* 5368, K. Schütte examines the distribution of the mean distances of the planets with large eccentricity. He finds that they are more numerous for values of n between 626″ and 650″, and between 776″ and 875″.

In *Ast. Nach.* 5397, N. Commendantoff (Leningrad) makes some suggestions for further international co-operation in obtaining the necessary observations of minor planets and calculations concerning their motion, in a systematic manner, without needless duplication.

A. C. D. C.

Report on Comets in 1925.

1925 was an *annus mirabilis* for comets, the number of discoveries during the year being eleven, which is one in excess of the previous record, viz., *ten* in 1898. The number of perihelion passages during the year is at least ten (equal to the number in 1898), and there are two others within 1½ days of the beginning of 1925 and 3 days of the end of it, respectively. It is quite possible that when definitive elements for the former are computed they may bring the perihelion into 1925 ; till this computation is made the definitive numeration of the 1925 comets remains in suspense. Of the eleven comets discovered in 1925, six were new comets and five were periodic ones detected on their return. There was only one periodic comet for which the search was unsuccessful, that of Schorr, 1918 III. It was so badly placed that failure was expected. The conditions at the end of 1931 will be much more favourable.

1925 *a* was discovered independently by Mr. G. Shajn at Simeis on

March 22, and by Professor J. Comas Sola at Fabry Observatory, Barcelona, on the 23rd. Both discoveries were photographic, and were made in the course of the regular search for minor planets carried on at the two observatories. It was very near the ecliptic when discovered, and its motion was slow; this made the orbit very difficult to compute, and the values of T first deduced ranged over fifteen months. It is now known to be 1925 September 7, nearly six months after discovery, so that the comet should be visible till the end of 1926 if not longer. Its magnitude was about 11 at discovery and 12·5 when it emerged from the Sun's rays in October: it is now about 13·5. Its perihelion distance was soon seen to be very large, actually 4·179, which is the greatest for any known comet, exceeding that of 1729 by 0·127 or $11\frac{3}{4}$ million miles.

1925 *b* was discovered by Mr. William Reid at Rondebosch, Cape Town, on March 24; it is his fifth cometary discovery, in addition to his detection of d'Arrest's comet in 1923. It was of magnitude 8, and was in S. Decl. 20° 16′ at discovery moving southward; it was, however, well observed in England by Dr. W. H. Steavenson, Mr. B. M. Peek, and Mr. G. P. B. Hallowes. Perihelion passage was at the end of July, when it probably attained naked-eye visibility. It was followed in the Southern Hemisphere till the end of the year.

1925 *c* was discovered on April 3 by M. Lucien Orkisz, assistant at Cracow Observatory, who was then at the small observatory on Mt. Lysina, 3000 feet high, near Cracow. It had passed perihelion on April 1 but approached the earth up till May 6; it became very well placed for northern observers, reaching N. Decl. 82° on May 31. It was a conspicuous telescopic comet of magnitude 8, with central condensation and a tail—diameter 4′ to 5′. It was followed till late in 1925, being of magnitude 13 on November 12.

1925 *d* was the periodic comet Tempel (2), which was found by Dr. Stobbe at Bergedorf on June 11, using the search ephemeris in the B.A.A. Handbook. E. Delporte found it independently at Uccle on June 12. It became quite bright in July, with a short tail, but then went too far south for observation in England. It was observed at Lick Observatory and in the Southern Hemisphere till nearly the end of 1925. This comet has been observed at every return since 1894, except 1910.

1925 *e*.—This was Wolf's periodic comet, discovered in 1884, and observed at every return since then, except 1905. It made a very close approach to Jupiter at its last aphelion passage, between 1922 July 8 and December 15; the resulting perturbations were most carefully and accurately calculated by Professor M. Kamiensky, director of the Warsaw Observatory; the eccentricity was diminished from 0·559 to 0·405, the period was increased by $1\frac{1}{2}$ years to $8^{y}\cdot282$, the perihelion distance was increased by a unit, these changes very nearly restoring the orbit to its computed shape and size before the approach to Jupiter in 1874. This is an interesting illustration of the fact that the Jupiter perturbations are reversible.

The computation of these great perturbations was so exact that Dr. W. Baade found the comet photographically at Bergedorf on July 13, within twenty seconds of time in R.A. and 0′·3 in declination of the

predicted place. The magnitude was 15, so the discovery would have been practically hopeless without an accurate ephemeris.

1925 *f*.—This was a return of Borrelly's periodic comet, for which MM. G. Fayet and A. Schaumasse had published an accurate search ephemeris (C.R. 1925 June 29). M. Schaumasse found the comet on August 14 at Nice; it was of magnitude 12, and the correction to the predicted T was −0·60 days. The comet subsequently brightened, and was followed for some time. It has been observed at every return since its discovery in 1905.

1925 *g*.—This was a return of Brooks's second periodic comet, discovered in 1889, and seen again in 1896 and 1903. In 1910 there was a single doubtful observation, while in 1918 it was not seen at all. This comet, like that of Wolf, made a very close approach to Jupiter at its last aphelion passage and suffered large perturbations. These were computed by Professor A. Dubiago, who deduced the date 1925 Nov. 8·5838 for the perihelion passage. This proved to be 5·94 days too late, but in comparing this result with that of Professor Kamiensky on Wolf's comet, it must be remembered that Brooks's had been virtually without observation since 1903, while Wolf's was observed for six months in 1911–12 and for four months in 1918. The comet was found on a photograph taken by G. Shajn at Simeis on September 9 in the course of the minor-planet work carried on there. Its identity with Brooks's was not recognised till V. Albitzky reobserved it on September 24. The magnitudes were 13·1 and 12·5 on the two days. The research of N. W. Storer and H. S. Mendenhall makes it doubtful whether the object of September 9 is the comet. If it is, the published position is some 13′ in error. The comet was well observed for some months.

1925 *h*.—This was a return of Faye's periodic comet. The comet had been missed in 1903 (too near the Sun), seen in 1910, missed in 1918, owing to Fontana's predicted date of perihelion being 46 days too early. Mr. F. R. Cripps calculated the perturbations from 1903 to 1925 and obtained the value for T., August 6·66, which proved to be only 0·90 day too early. Dr. W. Baade found the comet photographically at Bergedorf on October 20. Once the accurate place was known Dr. Stobbe re-examined earlier Bergedorf plates and succeeded in finding images of the comet on those of August 29 and September 15. Several other observations were subsequently obtained.

1925 *j* was discovered as a comet of the 8th magnitude by Professor G. Van Biesbroeck at Yerkes Observatory on November 17; he was setting for 1925 *c* Orkisz, and found this much brighter comet in the same region. Information of the discovery was broadcast by the B.B.C. in London the following evening, the sole clue to its position being the constellation "Hunting Dogs." This enabled Dr. W. H. Steavenson to find it by sweeping on the morning of November 18. The orbit, like that of 1925 *a*, was somewhat troublesome to compute, the difficulty here arising from the apparent motion being slow, and nearly in a line from the Sun. However, Messrs. J. P. Möller and Bengt Strömgren obtained an orbit from a 6-day arc that was quite near the truth. The comet had passed perihelion 1½ months before discovery, but it was approaching the earth, so that it did not fade rapidly. It was still an easy object

on January 6. A photograph by J. Rheden (Vienna) on November 20 showed a tail 34′ long (*Ast. Nach.*, No. 5411); a sketch by K. Graff (Bergedorf), made on November 24, reproduced in *Ast. Nach.*, No. 5412, shows a tail 15′ long.

1925 *k*.—This comet was actually found before the last, but the news was not circulated in Europe till after that announcement. The comet was found by Mr. L. C. Peltier at Delphos, Ohio, on November 13. He at once communicated the discovery to Harvard College Observatory, noting that the object was "certainly a comet." Harvard College sent the announcement to several American observatories, but they failed to find the comet, evidently because they looked too near the discovery position, the motion being very rapid. The news was not sent to Europe till after Mr. Wilk's independent discovery of the object on November 19 (at Cracow) had been telegraphed to Harvard. The above facts show that Mr. Peltier is entitled to have his name put first in the official designation of the comet. An image of the comet was found on a plate taken by MM. Guthnick and Prager at Babelsberg, on November 18, but apparently they did not detect it till the announcement of Mr. Wilk's discovery reached them. It was a conspicuous object of magnitude 7 or brighter, and was visible in twilight early in December. It was followed till nearly the end of the year, when it was lost in the Sun's rays. It may still be visible to southern observers when it emerges. The orbit makes a near approach to that of the Earth at the descending node.

1925 *l*.—This comet was found on the evening of December 13 by Mr. G. E. Ensor, X-ray operator at Pretoria General Hospital, an enthusiastic amateur astronomer. It was of magnitude 8, and had a tail 15′ long. It was in the constellation Reticulum, and was moving fairly rapidly to the south-west. A fine series of observations was obtained by Mr. H. E. Wood at the Union Observatory, Johannesburg, from which he deduced an orbit which was telegraphed to Europe. Perihelion passage is in mid-February 1926, but the comet will then be too near the Sun for convenient observation. It should be a fairly conspicuous object in the morning sky at the end of February; it advances into high north declination during March.

Several papers on cometary spectra have been published. In *Ast. Nach.*, No. 5345, G. A. Tikhov describes the spectra of Encke's comet in 1914 and 1924. The continuous spectrum was feeble, there was 1 strong cyanogen band, 3 of carbon, 1 of which was strong, and 1 of unknown origin. In *Ast. Nach.*, No. 5399, S. V. Orlov describes the spectrum of Morehouse's comet, 1908 III.; he gives a list of 39 lines due to carbon monoxide, 9 to nitrogen, 6 to cyanogen, and 5 to carbon (Swan spectrum). He shows that the CO lines can be arranged in 4 Deslandres series. In *Ast. Nach.*, No. 5356, S. Vsechsviatsky describes the spectrum of Brooks's comet, 1911 V. There were feeble bands due to carbon and carbon monoxide, the latter growing stronger as the comet approached the Sun.

The following table gives the elements of the comets of 1925, and those of some earlier comets published recently. The reference numbers are carried on from the sequel to Galle's *Cometenbahnen*, published last year as a B.A.A. Memoir.

Reference No.	499	503	529	530
Designation 1	1911 VIII.	1912 IV.	1918 III.	1918 IV.
Designation 2	1911 *e*	1912 *b*	1918 *d*	1918 *c*
Name	Borrelly	Tuttle	Schorr	Borrelly
T	Dec. 17·99357	Oct. 28·543002	Sept. 28·6031	Nov. 16·5911
ω	352° 21′ 48″	206° 57′ 21″	278° 38′ 47″	352° 23′ 3″
Ω	76° 49′ 36″	269° 42′ 55″	118° 0′ 33″	76° 49′ 11″
i	30° 26′ 27″	55° 2′ 58″	5° 35′ 2″	30° 29′ 26″
log q	0·1469515	0·0128104	0·274678	0·1448138
Period (years)	6·928777	13·52073	6·70712	6·90628
Equinox	1910·0	1910·0	1925·0	1910·0
Computer	G. Fayet	E. Heise	J. Larink	A. Schaumasse
Reference	*J.O.*, **8**, 109	*Dissertation Bamberg* 1920	*Bergedorf Mitt.*, **5**, 23	*J.O.*, **8**, 151

Reference No.	536	554	555	556
Designation 1	1919 V.	1924	1925	1925
Designation 2	1919 *c*	1924 *d*	1925 *c*	1925 *b*
Name	Metcalf / Borrelly	Wolf (2)	Orkisz	Reid
T	Dec. 7·31414	Dec. 30·1002	Apr. 1·4782	July 29·87740
ω	185° 44′ 56″	176° 31′ 0″	36° 9′ 12″	259° 16′ 56″
Ω	120° 58′ 26″	260° 12′ 18″	318° 3′ 12″	5° 59′ 43″
i	46° 23′ 20″	23° 59′ 30″	100° 0′ 48″	26° 58′ 18″
log q	0·0473727	0·387768	0·045049	0·213045
Period (years)	..	7·6575	..	6910
Equinox	1919·0	1925·0	1925·0	1925·0
Computer	W. F. Meyer	G. van Biesbroeck	J. Witkowski / K. Kordylewski.	C. J. Merfield
Reference	*L.O.B.*, **12**, 37	*A.J.*, **36**, 96	*Crac. Circ.*, 18	*A.N.*

Reference No.	557	558	559	560
Designation 1	1925	1925	1925	1925
Designation 2	1925 *d*	1925 *h*	1925 *a*	1925 *j*
Name	Tempel (2)	Faye	Shajn / Comas Sola	van Biesbroeck
T	Aug. 7·0436	Aug. 7·56 (1)	Sept. 7·21942	Oct. 2·77969
ω	186° 34′ 22″	199° 43′ 15″	205° 48′ 6″	106° 3′ 8″
Ω	120° 47′ 58″	206° 13′ 46″	357° 29′ 32″	334° 35′ 52″
i	12° 46′ 34″	10° 36′ 31″	146° 42′ 42″	49° 10′ 15″
log q	0·1183807	0·208161	0·621052	0·193266
Period (years)	5·16211	7·3178	..	..

Equinox	1925·0	1925·0	1925·0	1925·0
Computer	H. M. Jeffers	F. R. Cripps	A. C. D. Crommelin	G. Merton A. C. D. Crommelin
Reference	*H.C.B.*, 826	*B.A.A.J.*, **35**, 186	*B.A.A.J.*, **36**	*Obs.* **49**, 31
Reference No.	561	562	562	563
Designation 1	1925	1925	1925	1925
Designation 2	1925 *f*	1925 *g*	1925 *g*	1925 *e*
Name	Borrelly	Brooks (2)	Brooks (2)	Wolf (1)
T	Oct. 7·593 (2)	Nov. 2·644 (3)	Nov. 2·212	Nov. 7·894 (4)
ω	352° 25′ 25″	195° 48′ 59″	195° 54′ 7″	160° 43′ 16″
Ω	77° 2′ 7″	177° 25′ 36″	175° 25′ 26″	204° 6′ 7″
i	30° 30′ 40″	5° 42′ 45″	5° 32′ 52″	27° 18′ 2″
log q	0·142429	0·272887	0·269687	0·3863914
Period (years)	6·8838	6·938	6·9312	8·28232
Equinox	1925·0	1925·0	1925·0	1925·0
Computer	G. Fayet A. Schaumasse	A. Dubiago	N. W. Storer H. S. Mendenhall	M. Kamiensky
Reference	*Marseilles Circ.*, 973	*A.N.*, **223**, 63	*L.O.B.*, 370	*Pubs. Warsaw Obs.*, I.

Reference No.	564	..	Predicted
Designation 1	1925	1926	1925
Designation 2	1925 *k*	1925 *l*	
Name	Peltier Wilk	Ensor	Schorr
T	Dec. 7·265	Feb. 11·96992	May 27·90
ω	126° 25′	354° 53′ 53″	279° 30′ 48
Ω	140° 50′	282° 24′ 39″	117° 12′ 57″
i	144° 35′	122° 59′ 41″	5° 37′ 18″
log q	9·88270	9·508580	0·261716
Period (years)	..	..	6·60165
Equinox	1925·0	1925·0	1925·0
Computer	G. van Biesbroeck Struve	A. C. D. Crommelin G. Merton	J. Larink
Reference	*U.A.I. Circ.* 92	*U.A.I. Circ.*	*Bergedorf Mitt.*, **5**, 23

Designation (1) gives the year of perihelion passage; designation (2) gives that of discovery. The numeration of the comets of 1925 under designation (1) remains doubtful till definitive elements have been found for comet 554, fixing the year of its perihelion passage. The orbits given for 558, 561, 562 (first orbit) and 563 are predicted ones, T, and period having been approximately corrected by last year's observa-

tions ; the original values were (1) Aug. 6·66 ; (2) Oct. 8·193, 6^{y}·8853 ; (3) Nov. 8·5838, 6^{y}·9438 ; (4) Nov. 7·71895, 8^{y}·281866.

T is given in G.M.T. up to the end of 1924, and in U.T. from the beginning of 1925.

In the case of the new comets I have selected those orbits that are derived from the longest arcs.

It may be noted that of the last 8 comets discovered (excluding those of short period) 6 have retrograde motion. A. C. D. C.

Erratum in Last Annual Report.

M.N., **85**, 350. Comet Wolf : Ω *should read* 260°30′36″.

Errata in Sequel to Galle's Cometenbahnen.

P. 12. Comet 451, second orbit : Ω *should read* 223°27′0″.
P. 15. Footnote : *for A.N.* 197, *read* 198.
P. 22. Comet 545 : Discovery date *should read* May 16.
P. 23. Alter the reference number of No. 557 to 559.

A. C. D. C.

Solar Activity in 1925.

Sun-spots.—There has been a large and progressive increase in sun-spots during the year. The mean daily spotted area for the last six months was more than treble that for the first half of the year. The number of spotless days has decreased to 5 per cent., and faculæ have increased correspondingly with the spots. On December 26 the total area, corrected for foreshortening, of all the spots on the disc was over 5000 millionths of the Sun's hemisphere, an amount rarely equalled before in the Greenwich records even at maximum phase.

Eight naked-eye groups of spots were seen during the year ; their times of central meridian passage were :—

May 6, Oct. 20, Nov. 13, Nov. 24, Dec. 10, Dec. 16, Dec. 25, Dec. 28, and their corresponding latitudes :—
16° N., 19° S., 15° S., 17° N., 20° S., 23° N., 20° S., 23° N.

The average latitude of the spots throughout the year was about 20°. Spots nearer the equator than 10° were very rare. A small group in latitude 40° N. was seen during the last week of December. The average latitude of the spots and faculæ of the year 1925 indicates that the cycle has advanced about half way from minimum to maximum.

H. W. N.

The Prominences.—The mean daily areas in square minutes of arc derived from the Kodaikánal photographic records are shown below :—

	North.	South.	Total.
1925 January to June	2·98	2·26	5·24
July to December	3·46	3·42	6·88

The mean daily numbers were 16·8 and 17·6 respectively in the two half-years.

Compared with the year 1924 the above figures indicate an increase of 15 per cent. in areas, the southern hemisphere showing a marked increase in activity.

The distribution in latitude was different from that of the year 1924, the northern hemisphere differing from the southern in respect of the zones of activity. The maxima, however, are near 60° in both hemispheres. A secondary maximum is also shown near 30°.

Prominences showing metallic lines were recorded on 50 occasions. Of these 33 were in the northern hemisphere. All of them were observed between 11° and 40° of latitude.

546 displacements of the hydrogen lines were observed in the chromosphere and prominences as against 329 during 1924. Of these 307 were towards the red, 232 towards the violet, and 7 both ways simultaneously.

There has been a remarkable increase in the disturbances of the hydrogen and helium lines over the disc. The number of bright reversals of the H_a line in the neighbourhood of spots was 382, whilst the number of displacements observed on the disc was 108. Of the latter 88 were towards the red. D_3 was observed as a dark line on 167 occasions. The activity indicated by these disturbances during the second half has been nearly 30 per cent. in excess of that shown during the first half of the year.

Prominences projected on the disc as absorption markings again showed an increase over the previous year. Their distribution shows a dissimilarity between the northern and southern hemispheres. While there are two maxima in the northern hemisphere about 30° and 60°, there is only one maximum in the southern hemisphere, near 30°.

During the first half of the year there was an excess of prominence numbers in the eastern hemisphere and of areas in the western. During the second half-year both areas and numbers were in excess in the western hemisphere. In the case of H_a absorption markings, both areas and numbers showed an eastern excess during the first half-year and a western excess during the second half-year.

A. A. N.

Solar Research in 1925.

Solar Radiation.—An important series of papers from the Smithsonian Institution have been published. They are *Smithsonian Misc. Coll.*, 77, No. 3, Provisional Solar Constant Values; No. 5, Solar Variation and Forecasting, by C. G. Abbot; No. 6, Solar Radiation and Weather, by H. H. Clayton; and No. 7, Solar Radiation and the Weekly Weather Forecast of the Argentine Meteorological Service, by G. Hoxmark. These papers, together with one on Day to Day Fluctuations in the derived Values of the Solar Constant, by C. F. Marvin, and one on Smithsonian Solar Constant Values, by W. W. Kimball (*Monthly Weather Review*, July 1925), are critically reviewed in *Nat.*, **116**, 754, by F. J. W. W. Abbot points out that the results before 1919 must be discarded as not sufficiently accurate for establishing variation of the solar constant,

and most of the results used are in the first paper above, from Harquahala and Mount Montezuma. The deviations from the average are of the same order as the error of daily measurement, and Kimball points out that the six large deviations to which Abbot attaches importance are all in the lowest grade of observations, and also that correlation between the two stations is due not to agreement in short-period variations, but to a large drop at one epoch. Abbot supports his case for a variation of the constant by evidence for an association between changes of radiation and the appearance of sun-spots and faculæ. Clayton gives this in graphical form, and F. J. W. W. shows that this analysis is worthless, and that Clayton's success in forecasting would be just as good, we may suppose, if he left out sun-spots, since he uses also temperature observations from three American meteorological stations. Hoxmark's results show little correlation between forecast and sequel. Thus Abbot's claim for forecasting seems to fail, and indeed the existence of the variation in the solar constant is problematical; the large drop in 1922 may be real, or may be due to unaccounted-for atmospheric absorption, most of which occurs in the region of short wave-lengths where it is hardest to measure.

An article in *Nat.*, **115**, 853, on Periodicity in Weather and Solar Phenomena, concludes that when the evidence for the relationship of certain meteorological phenomena to solar cycles is submitted to exact mathematical analysis the results are usually negative.

The distribution of energy over the sun's disc has been the subject of a new investigation by W. J. H. Moll, H. C. Burger, and J. van der Bilt (*B.A.N.*, **91**). Measurements were made by them up to a distance from the limb of 1 per cent. of the sun's radius. Their values over the range measured by Abbot (up to 5 per cent. from limb) exceed his, and his defect from theirs is explained as due to the insufficient quickness of response of his galvanometer causing a lag tending to give too small results; this effect is investigated quantitatively by the writers.

J. Spijkerboer (*Arc. Neerl.*, **9**, 79) criticises the investigations of Lundblad (*Astroph. Jour.*, 1924) on the radiation from the external photospheric layers, remarking that (i) his equations relate to plane surfaces, (ii) the assumption that the influence of molecular diffusion is small is not justified.

Magnetism.—In *Nat.*, **115**, 537, L. A. Bauer remarks that terrestrial magnetism and atmospheric electricity in fine weather are more closely correlated than is usually supposed; the latter may be supposed correlated with solar activity, but it cannot be decided whether the potential gradient should be high or low for maximum sun-spottedness. C. Chree (*Nat.*, **115**, 982) expresses doubt whether terrestrial electric and magnetic quantities are known with sufficient accuracy to allow of finding any influence of sun-spots. C. G. Abbot (*Nat.*, **116**, 785), in reply to C. Chree (*Proc. Roy. Soc. A.*, **109**, 1925), remarks that we are to expect a low value of the solar constant to be associated with magnetic disturbance since the passage of a sun-spot group over the centre of the disc is associated with a decrease in the constant (*Smithsonian Misc. Coll.*, **77**, No. 5, 23), and doubtless frequently with magnetic storms.

A table of observations at Stonyhurst giving sun-spot areas and terrestrial magnetic horizontal ranges and disturbances in 1924 is published by the late A. L. Cortie (*Obs.*, **48**, 76).

Sun-spots, Faculæ, and Prominences.—The Forms and Motions of the Solar Prominences is the title of *Pub. Yerkes Obs.*, **3**, No. 4, containing the results of a study, mainly of the eruptive prominences, by E. Pettit. He finds that the accelerating force in the great prominence of 1919 May 29 was discontinuous, and from examination of all recorded observations of eruptive prominences that there is uniform motion and sudden impulses. J. Evershed (*Nat.*, **116**, 30) points out that the measures published in *Kod. Obs. Bull.*, **3**, 215, are not used by Pettit, but measures from half-tone prints. If the former are used the irregular motions disappear. Pettit also studies the lateral and internal motions, and finds that the velocity of descent of the streamers is about one-third to one-quarter of that which gravity would cause. He rejects radiation pressure as inadequate to account for the repulsive force, and suggests the periodic ejection of showers of electrons from a disturbed area as an agent.

R. K. Sur (*Nat.*, **116**, 395) explains the motions of prominences as due to radiation pressure from locally brighter portions of the photosphere, but J. Evershed (*Nat.*, **116**, 395) points out that some prominences come from regions where there is no evidence of such bright faculæ.

R. Sekiguchi, S. Itiki, and T. Taguti have investigated the motions of sun-spots (*Mem. Imp. Marine. Obs. Japan*, 2, 1, 1925), and find, on the basis of the Greenwich records, that a spot has a greater tendency to maintain its energy when in close connection with the underlying bed of slowly rotating matter. Much longer rotation periods than the usual ones are derived by these writers, and they ascribe this to a more swiftly moving upper layer carrying the spots, not allowed for in previous work. The levels and mechanism of solar disturbances are discussed and some speculations made.

From the Royal Observatory, Greenwich, is published a paper on the characteristic movements of sun-spots (*M.N.*, **85**, 553). The most remarkable feature is the rapid forward movement in longitude of a leader spot at its formation accompanied by its increase in area. Possibly a leader spot is high at formation and rapidly descends, increasing in area.

G. E. Hale and S. B. Nicholson, in *Astroph. J.*, **62**, 270, give a revised scheme of magnetic classification of sun-spots, tabulating the classification of 2174 spot groups. The $11\frac{1}{2}$ and 23 year periods are discussed by them, and also the law of spot polarity.

H. H. Turner re-examines (*M.N.*, **85**, 467), in the light of newer data, the solar cycles, and finds latitude variations in spots yield a period of 11·35 years, and areas yield 11·65 years, giving a mean value of very nearly 11·50 years.

T. Royds describes interesting features that are brought out by using a narrow slit set on one edge of the H line in obtaining spectroheliograms (*M.N.*, **85**, 464).

G. E. Hale decides that the hydrogen vortices surrounding sun-spots are hydrodynamical in nature rather than electrodynamical (*P.A.S.P.*, **36**, 268, and *Proc. Nat. Acad. Sci.*, **11**, 691).

A paper by W. H. Julius (*Arc. Neerl.*, **9**, 86) discusses further the influence of perspective in spectro-heliograms, and in *Arc. Neerl.*, **9**, 105, and *Proc. Amst. Acad.*, **27**, 150, he applies the dispersion theory to account for the Evershed effect in sun-spots.

N. Kosniev and V. Ambarzumian have developed (*A.N.*, 5406) a method of determining the height of faculæ from their variations in brightness.

The following records and summaries of observations have been published during the year 1925: Mean Areas and Heliographic Latitudes of Sun-spots in 1924, by the Royal Observatory, Greenwich (*M.N.*, **85**, 1006); Mount Wilson Magnetic Observations on Sun-spots (*P.A.S.P.*, **36**, 28, 92, 165, 225, 272); Sun-spot Activity during 1924, by S. B. Nicholson and B. W. Mayberry (*P.A.S.P.*, **36**, 34); Monthly Notes on Solar Activity, by C. P. Butler (*Obs.*, **48**, 1925); Observations of Spots and Flocculi (*Bol. Men. Obs. del Ebro*, 1925); Observations of Spots and Prominences in 1920 21 22 (*Ann. de l'Obs. Zo-Se*, **14**, 1); and in a note on three large spots in 1925 October and November, it is remarked that there was no magnetic disturbance at Greenwich associated with the transit of these groups across the disc (*Nat.*, **116**, 879), which is interesting in connection with the remark of C. G. Abbot, noted above under *Magnetism*.

Corona.—Several photometric measurements of the radiation from the corona were made during the total solar eclipse of 1925 January 24. J. Kunz and J. Stebbins, using a photo-electric cell, have compared the coronas of 1918 and 1925 (*Astroph. J.*, **62**, 114), and find no evidence of variation between sun-spot maximum and minimum. H. T. Stetson and W. W. Coblentz, using a thermo-couple, find (*Astroph. J.*, **62**, 128) proportionally more infra-red radiation is emitted from the corona than from the sun. Cosmic dust and metallic oxides ejected from the sun are suggested by them as possible causes for this effect. E. Pettit and S. B. Nicholson, also using a thermo-couple, found the radiation from the sun was less than that from the corona on the violet side of $1{\cdot}3\mu$, and that there was no appreciable radiation in the region beyond $5{\cdot}5\mu$. They also investigated the distribution of energy in the corona, and further conclude that there is reason to believe that the intensity of coronal light varies with the solar constant, but with a greater amplitude (*Astroph. J.*, **62**, 202, and *P.A.S.P.*, **36**, 152). These two results are not necessarily inconsistent, but only one of them can be consistent with that of H. Ludendorff, who publishes the results of measurements of the intensity of the radiation from the corona, using the plates taken at the eclipse of 1923 September 10. He finds no difference, not within the errors of experiment, between the intensity in the continuous spectrum of the corona and that of the sun (*Sitz. der Preuss. Akad.*, **5**, 83, 1925).

W. Anderson has examined various theories of the corona, and finds they all contain hidden difficulties. The observations of Ludendorff

agree with the electromagnetic theory, but there is a small discrepancy in the deduced molecular weight of the coronal material (*Zs. f. Phys.*, **31**, 273, and **34**, 453).

Spectroscopic Work.—The first fruits of the extensive programme undertaken at the Allegheny Observatory, mentioned in this note last year, have appeared in a list of Standard Solar Wave-Lengths from 4043 to 4754 A., by K. Burns and W. F. Meggers (*Pub. Alleg. Obs.*, **6**, No. 7). The method adopted was that of the grating crossed by a Fabry and Perot interferometer, and a very useful and illuminating discussion of the technique of this method is to be found in their paper. The measurements are being used to determine new standards, free from the irregular errors to which Rowland's measures are liable.

W. H. Julius criticises the introduction of differential diffusion by St. John as a cause of the red displacement of the Fraunhofer lines (*Arc. Neerl.*, **9**, 98).

Theoretical.—The form of the Fraunhofer lines is discussed by J. Q. Stewart and by E. A. Milne in *M.N.*, **85**, 732 and 739. Stewart criticises Milne's paper on this subject (*M.N.*, **85**, 111), objecting to his accounting for the widths by Doppler effect and the influence of random fields from neighbouring molecules, and to his assumption that the intrinsic width of a line is negligible. Stewart also derives the fundamental formulæ by classical electrodynamical theory. Stewart's criticisms are mainly based on a misunderstanding, and Milne in the second of these papers points out that his results do not depend on any particular assumptions as to line width; it is the residual intensity at the centre of the line which matters; he does not claim that the radiation pressure in the solar chromosphere supports enough ionised calcium atoms to account for the observed widths of the H and K lines, but that the residual intensities are accounted for. Were Stewart's estimate of the number of calcium atoms present used, the residual intensity would be practically zero, which is certainly not so.

S. Rosseland contributes an important paper on the Solar Magnetic fields to *Astroph. J.*, **62**, 387. He shows that the current picture of the general magnetic field as similar to that of an elementary magnet in each level is irreconcilable with ordinary magnetic theory, and proposes an alternative. The motion of an ionised gas must in general be accompanied by a current even if the gas is macroscopically neutral. This effect is too small to produce the fields observed, though if the sun were emitting long range α or β particles the possibility would be strengthened.

H. Faxen (*A.N.*, 5366) makes some mathematical criticisms of Lundblad's determination of the solar temperature (*Astroph. J.*, **58**, 1923).

G. Armellini considers a possible oscillation of the solar diameter (*Acad. Lincei*, **2**, 293).

Solar Rotation.—A further discussion of the determination of the solar rotation from long lived spots, including the last two cycles,

appears from Greenwich in *M.N.*, **85**, 548, with the conclusion that there is no difference in the derived rotation period due to the change of polarity.

J. Evershed, from measurements of the solar rotation at different levels, using Fe and the D lines, finds (*M.N.*, **85**, 607) the angular speed of rotation increases materially with height, as was found by Adams.

See also remarks on solar rotation in the paper by Sekiguchi, and others, noted under sun-spots, etc., above.

Eclipses and Tests of the Einstein Theory.—The report of the Sproul Observatory Eclipse Expedition of 1923 September 10 is published by J. A. Miller and R. W. Marriott, who find (*Astroph. J.*, **61**, 73), in addition to the usual polar rays, a sheet of light at each pole; the one at the North Pole breaks up into streamers with a very abrupt curve at the ends, in accordance with Miller's mechanical theory of the corona. Motions were measured in a disturbed region of the corona, which was above a sun-spot observed at Mount Wilson. The H_α line in the flash spectrum showed over an arc of 56°, and there was no very strong radiation between H_α and 8500 A. Shadow bands were also observed.

The following observations of the eclipse of 1925 January 24 have been published:—

H.C.O. Circ., 286, contains the report of the Harvard results, by E. S. King (also in *Pop. Ast.*, **33**, No. 5); the coronal radiation inside a circle of three degrees was measured, and its colour index, and also the times of contact. Photographs were taken through a silvered quartz lens to investigate the ultra-violet radiation. The *Jour. R.A.S. Can.*, **19**, contains on p. 59 a report by R. M. Stewart of the Dominion Observatory Expedition, who observed magnetic effects and possible disturbances of wireless wave transmission; on p. 62 some other reports of observations of this eclipse are collected, and on p. 98 are some observations of shadow bands. Times of first and last contact are given by J. A. Porter in *Ast. Jour.*, 851. Other reports of observations are in *P.A.S.P.*, **36**, 41, and by Felix de Roy in *Gaz. Ast.*, 135, 1925.

Miscellaneous.—In *Obs.*, **48**, there has been a discussion on the height of the chromosphere. Milne takes the height of Ca+ to be 14,000 km., on the basis of Mitchell's results, and on p. 45 J. Evershed maintains that this is an overestimate; S. A. Mitchell defends his results in a reply on p. 108, and remarks on the correct interpretations of the results are contributed by A. A. Buss on pp. 110 and 222. Milne raises the question (p. 145) of what is to be meant by "the height of the chromosphere?" and observes that the height variations mentioned by Mitchell are in accordance with his own work (*M.N.*, **85**, 133). Evershed points out (p. 146) that the chromosphere is not by any means a uniform envelope, but consists of jets and miniature prominences, the height is always near 8000 km., and the variation is doubtful. A. L. Cortie (p. 148) states that he found a slight increase in extent of H_α from 1880 to 1883, and signs of elevation and depression are common over considerable areas of the limb near times of sun-spot maximum and minimum.

Progress in solar research at Meudon forms the subject of an article by H. Deslandres in *C.R.*, **181**, 583.

Mlle. St. Maracineanu finds (*C.R.*, **181**, 774) an influence due to solar radiation on the radioactivity of lead and uranium.

W. H. Eccles finds from observation during the eclipse of 1925 January 24 that the Heaviside layer is not effective in the transmission of wireless signals (*Nat.*, **115**, 260).

Ultra-violet radiation from the sun at great altitudes, and masses of absorbing vapour at great heights, are the subjects of investigations by J. Lecarme (*C.R.*, **180**, 47 ; **181**, 1079).

J. A. C.

Stellar Spectroscopy.

Novæ.—Nova Pictoris, 1925. This Nova was discovered on 1925 May 25 by Mr. Watson of Beaufort West, S. Africa, when it was of estimated magnitude 2·4. Prior to outbreak it appears to have been an uncatalogued star near C.P.D. −62°679 (*H.C.O. Bull.*, 821), and of photographic magnitude 12·7 (*H.C.O. Bull.*, 823). On 1924 December 26 it was fainter than 11th magnitude, and on 1925 April 13 it was magnitude 3, and on May 27 about magnitude 2. The spectrum is in many respects unusual. In its later stages, instead of passing to the stage in which the nebular bands at 4363 and the 4641 group are the most prominent features associated with the H bands, this Nova resembles that of η Argus, and the usual nebular bands are absent. Very many observations are recorded. E. W. Cooke (*M.N.*, **85**, 895) reports a plate covering the region of the Nova on 1924 March 1, showing an image, probably that of the Nova, of magnitude 14·2. W. H. Wright has written an article on the Nova, illustrated with plates of the spectrum, in *P.A.S.P.*, **36**, 235, in which comparison of its features with those of other Novæ is made. An account of the discovery and early stages is given by H. Spencer Jones in *Obs.*, **48**, 261, and further reports from various sources appear in *Obs.*, **48**, 316, 319, and 347. Remarks on and observations of the Nova appear in *Journ. B.A.A.*, **36**, 30; by J. Hartmann, *A.N.*, 5379; *Un. Obs. S. Africa. Circ.*, 64; *H.C.O. Bulls.*, 821, 822, 823, 824, 826, of which the last gives the colour-index of the Nova on 1925 September 7 and 15 as −0·30 and −0·45, *i.e.* it was of earlier type than Bo.

Nova Cygni (1920).—Observations are recorded by W. H. Steavenson (*M.N.*, **85**, 662), and by A. A. Nijland (*B.A.N.*, 80).

Nova Persei (1901).—Observations during 1924–5 by W. H. Steavenson (*M.N.*, **85**, 665) show that this Nova has been strikingly faint, rising only once above magnitude 13·0 after 1924 July 21. Its fluctuations have been more rapid and less regular than during the past three years. Similar results are found in the observations of A. A. Nijland (*B.A.N.*, 80) and B. M. Peek (*M.N.*, **85**, 666).

Nova Aquilæ (1918). —Plates showing the spectrum of this star are given, with descriptions and measurements (1918 June 9 to 1918 August 10) in *Un. Obs. S. Africa. Circ.*, 62. Other observations are in *M.N.*, **85**, 662, and *B.A.N.*, 80.

Nova Aquilæ (1925).—This Nova was invisible on a plate of 1925 August 25 at Harvard; on September 8, it was of photographic magnitude 9·8, it reached maximum at 9·2 on September 23, and its spectrum resembles that of N Pictoris in its early stages (*H.C.O. Bull.*, 826). Other observations are those of M. Wolf (*A.N.*, 5395 and 5401).

Other publications of observations of Novæ are :—W. H. Steavenson, N Cassiopeiæ 1572, N Ophiuchi 1848, N Cygni 1876, N Lacertæ 1910, in *M.N.*, **85**, 662.

B. M. Peek, N Ophiuchi 1848, N Cygni 1876, in *M.N.*, **85**, 666. A. A. Nijland, N Lacertæ 1910, N Ophiuchi 1919, in *B.A.N.*, 80.

N. Barabascheff discusses further his pulsation theory of Novæ, and shows the fit of some more Novæ to his theoretical curve (*A.N.*, 5365).

Photometry and Spectrophotometry.—Considerable progress has been made in determining the distribution of energy in the spectrum of a star. Photographic spectrophotometry forms the basis of two lines of attack. R. A. Sampson has developed (*M.N.*, **85**, 212) the use of a photo-electric cell to measure densities in the photograph of a stellar spectrum, whence the energy curve can be obtained, and temperatures deduced. His results are of the order of magnitude found by other methods, though the temperatures of the hotter stars are found to be rather in excess of other results, but not so high as is required by R. H. Fowler and E. A. Milne's theory. This paper, giving the temperatures of 64 stars, is a continuation of earlier work (*M.N.*, **83**, 1923), which it confirms and extends. It also indicates the directions in which more work is required. The law of blackening of the plate used is discussed by E. A. Baker (*Proc. Roy. Soc. Edin.*, **45**, 166).

W. M. H. Greaves and C. R. Davidson have applied the method of a prism crossed by a grating to the same problem in order to find the sensitivity of the plate readily. They give (*M.N.*, **86**, 33) preliminary results, which are in accord with others. The evaluation of the atmospheric absorption has proved difficult.

W. W. Coblentz gives in *Nature*, **116**, 439, some results of radiometric measurements of the stellar energy spectrum made at the Lowell Observatory in 1921, using absorbing screens to separate spectral regions. He finds temperatures from 2500° K for red stars to 14,000° K for blue stars.

It is worth noting that while direct bolometric measurements are desirable they are limited to very bright stars, and that, though photography enables one to investigate fainter objects, the plate sensitivity can only be determined with difficulty. Moreover, in all these methods the resolving power that can be used is such that the results are necessarily, in the later type stars, very much an average through absorption lines, and not purely the intensity in the continuous spectrum, to which defect the direct bolometric methods are most liable.

F. W. Dyson and E. Martin, continuing the work of Davidson and Martin on effective wave-lengths of stars from Dec. 80° N. to the north pole, find (*M.N.*, **86**, 28) that redder stars are of greater luminosity than blue stars of the same HD spectral class, but the difference is not

sufficiently definite to be used as a criterion of luminosity in particular cases.

A. Brill (*A.N.*, 5386) correlates the measures of stellar temperatures of Sampson, Coblentz, Bottlinger, Rosenberg, Brill, and Hertzsprung.

The effective wave-lengths of about 1020 faint stars in the Milky Way near Aquila have been measured by J. H. Petersson (*Arkiv. Svensk. Akad.*, **19**, 3), who discusses their distribution, and compares the Aquila cloud with the Hyades, Præsepe, and M 11. The faintest stars were of photographic magnitude 13·0, and from the A-type stars the distance is found to be 1500 parsecs.

Methods used in stellar photographic photometry at the Yerkes Observatory 1914–24 are described by the late Mr. J. A. Parkhurst and Alice H. Farnsworth in *Ap. J.*, **62**, 179.

The reduction of the Harvard visual scale of magnitudes to the Mount Wilson photo-visual system has been effected by F. H. Seares (*Astroph. J.*, **61**, 284), who, together with M. C. Joyner and M. L. Richmond, has reduced the Harvard-Groningen Durchmusterung to the International system of magnitude and colour.

Standards of magnitude for the *Astrographic Catalogue* are being extended to the southern hemisphere by Miss H. S. Leavitt (*H.C.O. Ann.*, **85**, 143), using observations both in Cambridge, Mass., and in Arequipa, to reduce the results to a uniform scale.

H. H. Turner, in a provisional general survey of counts for 40 zones of the *Astrographic Catalogue*, finds (*M.N.*, **85**, 471) that the galactic concentration is not the only systematic feature in stellar distribution.

R. M. Motherwell describes the methods of stellar photometry with a 6-inch doublet at Ottawa (*Pub. Dom. Obs. Ott.*, **8**, No. 7, 117), and gives a table of results for about 120 stars between magnitudes 5·1 and 8·2 with a probable error of about 0·01 independently of spectral type. His results agree very closely with those of Parkhurst at the Yerkes Observatory.

G. Shajn and Miss V. Hase find that the colours of stars of types B and A do not show much dependence on their luminosity (*A.N.*, 5394).

In *A.N.*, 5404, G. Shajn reports the results of observations of C.I. of double stars at Pulkovo, and discusses his method of deriving parallaxes. He finds that the stars fit a Russell diagram. E. Öpik and R. Livländer discuss determinations of colour equivalents by Tikhoff's method (*Pub. Obs. Tartu.*, **26**, 1925), and find two kinds of colour equivalent from photometric observations, whence, with proper motion and magnitude, the absolute magnitude is derived to ±0·6 mag.

Absolute magnitudes of nebulæ, clusters, and peculiar stars in the large Magellanic cloud have been determined by H. Shapley and Harvia W. Wilson (*H.C.O. Circ.*, 271), and together with I. Yamamoto they publish (*H.C.O. Circ.*, 280) a photographic period-luminosity curve for the stars in the Magellanic clouds of periods between 1 and 40 days. The distance of the small cloud on the new basis is 32·3 kilo-parsecs.

A list of 62 stars fainter than photographic absolute magnitude 10 is given by A. van Maanen (*P.A.S.P.*, **36**, 24), and to these W. J. Luyten adds another 30 (*P.A.S.P.*, **36**, 82).

Spectroscopic Binaries.—The *Publications of the Dominion Astrophysical Observatory, at Victoria*, contain the results of many determinations of orbits. S. Smith gives (**3**, 164) the orbit of Boss 6070, J. A. Pearce gives (**3**, 171) the orbits of the components of HD 216014, the spectral type of which he finds to be Bo. n., J. S. Plaskett gives (**3**, 180) the orbits of τ_2 Coronæ Borealis and HD 25833 of which the distances are about 2000 light years, which is greater than that usually accepted for stars of this type (B), W. E. Harper has determined (**3**, 190) the orbits of 45 Aurigæ, 19 Leonis Min., 105 Herc., 22 Vulpec., and π Cephei, also Boss 1452 (**3**, 159), τ Aurigæ (**3**, 151) a plate showing the spectrum of which is given, and 5 Tauri (**3**, 145). In *Journ. R.A.S. Can.*, **19**, 1, the orbits of Boss 804, 1190, 1452, and 5192 are published by W. E. Harper, and on p. 46 the spectroscopic binary 12 Lacertæ is found, in new observations by R. K. Young, to show stationary calcium lines.

E. B. Frost and O. Struve find (*Ap. J.*, **60**, 313) the orbit of 66 Eridani, both components of which are of class B9; there are sharp K lines, and no stationary K component exists.

The orbit of 16 Lacertæ is given by O. Struve and N. T. Bobrovnikoff (*Ap. J.*, **62**, 139); the H and K lines show a stationary velocity of −18·9 km./sec.

R. F. Sanford records the orbits of Boss 1131, HD 101206, B.D. +55 2215, and β G.C., 9818 S (*Ap. J.*, **61**, 320).

F. Henroteau, in a third paper on the system σ Scorpii, finds that it is a real triple system; it may be considered as a Cepheid and has stationary H and K lines (*Pub. Dom. Obs. Ottawa*, **9**, No. 2, 91).

Measures of the spectroscopic binary Mizar by the interferometer are given by F. G. Pease (*P.N. Acad. S.c.*, **11**, 356; and *P.A.S.P.*, **36**, 155).

Spectroscopic Parallaxes.—G. Shajn has used determinations from 55 late- and 139 early-type double stars to test the derivation of absolute magnitude and parallax. He finds that the derived parallaxes are very satisfactory for the later types, the error being 14–25 per cent., but for the A and B types it is 65–77 per cent. The correlation between spectral type and absolute magnitude in types A and B is evident for such stars moving in clusters, but less so for individual stars of known parallax, which show large deviations from the reduction curve and considerable dispersion of absolute magnitude (*Ap. J.*, **62**, 104).

R. K. Young and W. E. Harper publish (*Pub. Dom. Astrophs. Obs.*, **3**, 1) the absolute magnitude and parallaxes of 1105 stars of type F to M including a few of type A. Nine lines in addition to the Mount Wilson five were used, and a new relation based on radial velocity, total proper motion, and distance of a star from the apex is found to be better than a formula connecting the parallax with the components of the proper motion. For 920 of the stars proper motion data are available as a test, and some are in common with the Mount Wilson determinations. Substantial agreement is found except for giants of late K type.

W. B. Rimmer has investigated the luminosities and parallaxes of 525 stars of type Fo to M*b* (*Mem. R.A.S.*, **64**, 1). The basis of the results is given, and comparisons with other determinations for the

237 stars for which other determinations exist. Some of the F-type stars are classified into three groups of special peculiarities.

D. L. Edwards has published (*M.N.*, **85**, 439) a second list of 100 parallaxes of B-type stars. To check the reduction curves some stars of known trigonometric parallaxes were measured, and no correction was found to be needed. The author concludes that the method of Adams and Joy seems to be the best at present available for the B-type stars.

A method of determining the luminosities and parallaxes of early type stars is developed by R. E. Wilson (*Astr. Journ.*, 847), on the basis of a new formula, resulting in an improvement in the method of passing from spectra to absolute magnitude for early types of stars with very small or very large proper motion. The Mount Wilson formula takes into account only the principal relation among the group of facts embraced by Wilson's formula.

A method of determining parallaxes from spectra of small dispersion is described by Rev. H. Macklin (*M.N.*, **85**, 444); the results agree best with trigonometric values for stars of great absolute magnitude independently of spectral type.

The parallaxes and radial velocities of 167 dwarf stars of type K5 or later have been published by W. S. Adams and A. H. Joy (*P.A.S.P.*, **36**, 157).

P. J. van Rhijn, in discussing (*Obs.*, **48**, 112) the observational facts on which the giant-dwarf theory is based, gives reasons for believing that red stars of luminosity intermediate between that of the giants and dwarfs can exist, but are not to be expected among the stars observed up to the present, and that while the frequency of absolute magnitude has a minimum between -1 and $+4$ there is not necessarily a gap. E. Hertzsprung in expressing his agreement with the views of van Rhijn (*Obs.*, **48**, 165) points out that if there exists a gap in the distribution we shall obtain a Russell diagram, but that the converse is not true.

Theory of Spectra and High-Temperature Ionisation.—E. A. Milne has investigated (*M.N.*, **85**, 750) the absorption coefficient of stellar interiors by applying Kramer's theory of the X-ray absorption coefficients to a highly ionised gas. The formula differs from that of Eddington by a factor of three, thus reducing the discrepancy between it and the astronomical value from a factor of 8 to one of 2 or 3. Eddington's theory of nuclear capture, when corrected for the ionisation potentials of the atoms, leads to values 2·4 to 8 times the astronomical value.

Further light on this problem, which is of fundamental importance in formulating a theory of the interior of a star, has been shed by the paper of S. Rosseland (*Ap. J.*, **61**, 424). The method used by Rosseland is to generalise from X-ray absorption experiments, and check the results by the experiments of Anderson (on the absorption by gases at high temperature formed by exploded wires), and of Harrison (on continuous absorption beyond the series limit). Thus he obtains an expression for the flux of radiation in a star, and finds that the absorp-

tion coefficient shows the same dependence on temperature, density, and atomic number as the one derived by Eddington. The difference between the numerical results is not large, and Rosseland thinks it likely that the core of a star consists of a disproportionate concentration of heavy elements, or of hydrogen which would produce the same effect.

In *M.N.*, **85**, 541, Rosseland discusses the distribution of hydrogen in a star. The possible metastability of certain states of the hydrogen atom will not suffice to account for the peculiar behaviour of the lines in stellar spectra. The peculiarity of hydrogen is that it has, in its ionised state, a ratio of charge to mass twice that of any other element, so that when another element is at a maximum of concentration hydrogen may be just the opposite. Thus, if the core of a star in hydrostatic equilibrium does not contain an enormous proportion of hydrogen it must all be repelled from the core and strongly concentrated on the outside.

J. Woltjer shows that line absorption may affect the value of Rosseland's integral for the absorption coefficient to the extent of accounting for the discrepancy between it and the observed value (*B.A.N.*, 82); but this calculation is made possible only at the expense of losing the derivation of the dependence of the coefficient upon density and temperature involved in Eddington's mass-luminosity function.

E. A. Milne shows that in the calculation of a mean absorption coefficient from that for a pure element, account must be taken of the proportions of the constituents (*M.N.*, **85**, 979).

In *B.A.N.*, 73, Woltjer reaches the conclusion that the energy which a star gains by contraction is used not only to augment the molecular and radiant energy content, but also to furnish the energy required for the progressing ionisation, so that possibly nothing remains available for radiation.

In *M.N.*, **85**, 768, E. A. Milne applies to the outer layers of a star the formulæ deduced in his paper *M.N.*, **85**, 750. He finds (i) the absorption coefficient for the region of continuous absorption beyond the limit of the Balmer series; (ii) in agreement with Jeans, the ratio of gas pressure to radiation pressure rapidly becomes nearly constant in the *immediate* interior, where the latter is about twice as important as it is in the far interior; (iii) the mass absorption coefficient is zero at the boundary, but rapidly becomes constant in the immediate interior, and it appears that if the application of the Eddington-Kramers formula is allowable then photo-electric absorption is the dominant cause of general absorption in a stellar atmosphere; (iv) a simple formula for the pressure in any star at the level of complete opacity is found; (v) the temperature difference between a giant and a dwarf star of the same spectral type is deduced (for Go it is 600°); (vi) tables giving the pressure, temperature, and ratio of gas pressure to radiation pressure at various levels in the Sun and in Capella are given.

R. H. Fowler gives (*M.N.*, **85**, 970) the earlier formulæ for the maximum of stellar absorption lines in a more exact form, and the maxima of certain lines are shown to be at lower temperatures than observation indicates. Another correction to the ionisation formula is pointed out by E. A. Milne (*Phil. Mag.*, **50**, 547).

J. H. Jeans points out that a continuous spectrum does not need a solid body for its source. The mechanism of its production in a star is the absorption and re-emission of radiation. Any gas can emit a continuous spectrum if its optical thickness (or opacity) be sufficient (*Obs.* **48**, 44).

P. A. M. Dirac shows that the effect of Compton scattering by free electrons in a stellar atmosphere is to produce wings to a line and not a shift, but the intensity of the wings so formed is insufficient to account for the observed widths of solar lines (*M.N.*, **85**, 825).

Numerical tests are found by J. Woltjer to reveal nothing improbable in the theory of interstellar clouds of calcium ionised by radiation from hot stars and so producing the stationary H and K lines (*B.A.N.*, 73).

A. Pannekoek and J. J. M. Reesinck contribute studies on line intensities in stellar spectra in *B.A.N.*, 79, where classification is based upon two parameters of temperature and gravity, and in *B.A.N.*, 87, some Cepheids are studied on these lines, with the conclusion that a large mass, in accordance with the relation of Eddington, cannot plausibly be assigned, and their masses may even be less than that of the Sun. Possibly radiative equilibrium cannot be assumed.

K. T. Compton points out that certain equations relating to cumulative ionisation deduced by him are not applicable to stellar atmospheres (*M.N.*, **85**, 547).

The emission of hydrogen and ionised helium from a star is found by M. C. Johnson (*M.N.*, **85**, 813) to be due to stimulation by electrons returning after being freed from doubly ionised atoms at high levels.

M. N. Saha (*M.N.*, **85**, 977), in reply to M. C. Johnson (*M.N.*, **84**, 516), maintains that the latter's criticisms of his work on the steric factor and ionisation in stellar atmospheres cannot be sustained.

M. N. Saha and R. K. Swe discuss the problem of ionisation equilibrium when radiation is producing most of the ions (*Nature*, **115**, 377), and J. Woltjer derives the same result as they do, starting from Einstein's paper on Planck's law and Milne's extension of this to the photo-electric effect (*Nature*, **115**, 534).

W. S. Adams and A. H. Joy find the maximum intensity of certain lines of enhanced silicon to occur at about type B 8 (*P.A.S.P.*, **36**, 163); there may be an association of these lines with absolute magnitude.

The possibility of obtaining data for use in the quantum theory from observations of the continuous spectrum of hydrogen in celestial spectra is discussed by J. W. Nicholson (*M.N.*, **85**, 253).

Classification.—The stars of class Be are of interest on account of the possible assistance they may give in the interpretation of the typical nova spectrum, and also because bright lines appear to be sensitive indicators of the conditions in stellar atmospheres; moreover, unusual properties of hydrogen atoms may be involved. Their discovery and observation is the subject of a paper by P. W. Merrill, M. L. Humason, and C. G. Burwell (*Astroph. J.*, **61**, 389), in which they announce the discovery of more new bright line stars than the number previously known in the areas observed. These stars show a tendency to fall into

groups near the centre line of the Milky Way, and the spectral classes Bo–B5 are the most favoured ones.

Miss P. Fairfield considers the relation of hydrogen line widths to absolute magnitude for A-type stars in *H.C.O. Circ.*, 264, and finds the Harvard estimates of line-width and the Mount Wilson description of line character are in close agreement. The correlation of line character of A-type stars with absolute magnitude is found to arise in systematic differences in classification. The intrinsic luminosity changes rapidly with Harvard class of spectrum, and line width is of no value in estimating the absolute brightness of individual A-type stars. The average of large numbers of stars shows a correlation of line character with reduced proper motions, which, however, may indicate dependence on linear speed rather than on intrinsic brightness.

W. J. S. Lockyer has made (*M.N.*, **85**, 580) a special study of the spectrum of ϕ Persei (of type Bope). Changes in the relative intensities of the components of the hydrogen lines bring out the binary nature of the star. The period given by Cannon and Jordan is corrected, and a list is given of ten other B-type stars having ionised iron as the brightest metallic lines.

A list of eighty-four dwarf stars of type M, giving name, position for 1900, Harvard visual magnitude, spectral class, and total annual proper motion, is published by W. J. Luyten (*M.N.*, **86**, 48).

The cluster M 11 has been studied by R. J. Trumpler (*L.O.B.*, 361). It belongs to the richer class of open galactic clusters, and the paper gives details of spectral classification, magnitudes, star counts, density distributions, and luminosity law. The derived parallax is $0''{\cdot}008$.

The first results of the extension of the Henry Draper Catalogue, as described in *H.C.O. Circ.*, 278, have been published by Miss Cannon in *H.C.O. Ann.*, **100**, No. 1.

Studies of particular stars published in 1925 are :—A study of the changes in the spectrum of T Centauri, by Leah. B. Allen (*L.O.B.*, 369). G. D. Shajn finds the spectrum of TU Tauri composite (N*b* and A*o*), and the separation of the components is less than $3''$ (*P.A.S.P.*, **36**, 35). The spectra of B.D.$+2°{\cdot}418$ and the faint companion of γ Ceti have been investigated by P. van de Kamp (*P.A.S.P.*, **36**, 99), who finds that the latter is of class M*b* and that the parallax agrees with the proper motion in indicating a physical connection. The spectrum and radial velocity of W Virginis are discussed by A. H. Joy (*P.A.S.P.*, **36**, 156); the star is a Cepheid of type cGo, the hydrogen lines are bright when the star is tending to a maximum; Boss 1985 has a spectrum like that of W Cephei (A. H. Joy, *P.A.S.P.*, **36**, 161). P. W. Merrill finds (*P.A.S.P.*, **36**, 163) some unknown bright lines in the spectrum of HD 45677, and the hydrogen lines show two components. S. Doradus is announced in *H.C.O. Bull.*, 814, to be a super-giant variable of absolute magnitude $-8{\cdot}9$ and distance 100,000 light years. Two stellar spectra of P Cygni type are noted by P. W. Merrill in HD 51480 and DM $-27°{\cdot}11944$ (*Astroph. J.*, **61**, 418). A note on B.D. $+15°{\cdot}2503$ appears in *P.A.S.P.*, **36**, 218.

The spectral classification of faint stars in the Milky Way near Aquila has been undertaken by G. Schalen (*Arc. f. M.A.F., Stockholm*, **18**, 36, 1), who finds their distance to be 965 parsecs.

Radial Velocities.—J. Woltjer has examined (*B.A.N.*, 75) the possibility of a gravitational shift of the spectrum lines of O- and B-type stars as an explanation of Kienle's relation between radial velocity and spectral type, and finds that it must be rejected.

Leah B. Allen publishes (*L.O.B.*, 369) the radial velocities of twenty southern variable stars of class *Me*. The radial velocities of one F and fourteen A-type stars are found by S. Smith (*Pub. Dom. Astroph. Obs.*, **3**, 167). Two red variables, R Pictoris and S Carinæ, are noted by Leah B. Allen (*P.A.S.P.*, **36**, 94) as having the high velocities of +204 and +280 km./sec. J. H. Moore gives the radial velocities of six planetary nebulæ in *P.A.S.P.*, **36**, 225, and R. F. Sanford gives that of N.G.C. 6760 in *P.A.S.P.*, **36**, 270.

M. Hamy discusses in *C.R.*, **180**, 345, the use of solar lines in radial velocity measurements, and H. Vogt discusses in *A.N.*, 5367, the K effect and the red calcium lines.

P. van de Kamp notes a star, H.O. 78753, with variable radial velocity (*P.A.S.P.*, **36**, 97).

Theoretical and Special Investigations.—The problem of the physical constitution of the stars has greatly occupied the attention of investigators. J. H. Jeans regards Eddington's results as due to special assumptions, and he has developed (*M.N.*, **85**, 196) a relation between mass, luminosity, and surface temperature, the last of which plays but a minor part in Eddington's theory. In this way he proposes to re-establish the giant-dwarf evolutionary sequence. Jeans objects to Eddington's assumption that the ratio of radiation pressure to gas pressure is constant throughout a star (a note in additional justification of Eddington's assumption is published by J. Q. Stewart, *Nature*, **116**, 314), and finds on discarding it that the mass-luminosity relation disappears. Eddington, who claims that the observational data confirm his results, remarks (*M.N.*, **85**, 403) that while a change in the particular assumptions he makes naturally leads to different results, it is not true that a change trifling from the physical point of view will lead to widely different results, and, unless the theory of the stellar absorption coefficient is rejected completely, it is not possible for the analysis to lead to anything much different from his relation.

To supply the energy needed by a star the conversion of matter into energy of radiation is invoked, but the actual laws governing the rate of generation of energy within a star are the subject of vigorous debate. Jeans maintains that a star generating energy at a given rate can always adjust its radius and surface temperature so as to be in equilibrium, but Eddington observes that the formulæ lead to instability in this case (*Nat.*, **115**, 494).

To determine the effect of error in the assumed distribution of the source of energy in a star, Eddington (*M.N.*, **85**, 408) takes the extreme example of a point source situated at the centre, and finds it unimportant so that the discrepancy between the theoretical and observational values of the absorption coefficient cannot be accounted for by this means.

Jeans concludes (*M.N.*, **85**, 792) that the only result of introducing the effects of radiation pressure into a theory of stellar interiors is to

correct quantitatively the qualitatively correct results yielded by a simple gaseous sphere.

To obtain the giant-dwarf sequence of evolution Jeans postulates the existence of two or more kinds of matter in a star, which can change into radiation at different rates (*M.N.*, **85**, 400), and he argues that the generation of energy per unit mass of a star is not a function of temperature or density, as required by Eddington's and Russell's theories, but that it is a function of the state of development of a star. On this assumption (*Nature*, **115**, 296), and in reply to F. A. Lindemann (*Nature*, **115**, 229), he shows that in this way the existence of the radio-active elements may be accounted for despite the great length of stellar life deduced by him.

In Eddington's view (*Nature*, **115**, 419) this cannot be so, since (i) observation shows that the rate of emission of energy by a star is closely correlated with its *present* state, and (ii) for the reason of instability mentioned above.

H. N. Russell shows that the formulæ of Eddington and Jeans are not inconsistent (*M.N.*, **85**, 935), and that while Eddington's conclusion that the rate of generation of energy must adjust itself for stability (and not the size and temperature of the star, which is Jeans' view) is correct for massive stars, it may fail for stars of small mass.

The effect of electrostatic forces in a star on the deviations of its constituents from the gas laws is found by Eddington (*M.N.*, **86**, 2) to result in a correction of about half a magnitude to the luminosity of the faintest stars in a direction which slightly improves his results.

A theory of stellar evolution is developed by Jeans (*M.N.*, **85**, 914) on the assumption of a constant rate of generation of energy within a star, and in a diagram the course of a star is demonstrated, and the limiting regions for the existence and stability of stars are determined.

An interesting discussion of the problem of stellar evolution by H. N. Russell appears in *Nature*, **116**, 209, where he remarks that while the rôle of opacity in determining the surface temperature of a star is agreed upon, the distribution of energy and its rate of generation are uncertain. Eddington's theory indicates that a star of given mass must have a definite absolute magnitude, but may have any radius, surface temperature, or spectral type, and that while the mass-luminosity relation is observationally confirmed, it is not true that stars of a given mass or absolute magnitude are distributed indiscriminately among spectral classes. It seems therefore necessary to assume that the rate of transformation of matter into radiation is a function of temperature, hence he develops a theory of stellar evolution.

A. Brill finds (*Zs. f. Phys.*, **34**, 676) that only one kind of constituent matter in a star is needed to explain the observational material, and he also has developed (*Zs. f. Phys.*, **31**, 717), in terms of Eddington's theory, a connection between spectral type, surface temperature, absolute magnitude, mass, etc., and finds that the product of the mass-absorption coefficient and the square root of the energy radiated per gramme per second is nearly constant for all stars.

A most interesting research in view of the possibility, on Eddington's theory, of the existence of stars of enormous density has been carried out

by W. S. Adams (*Proc. Nat. Acad. Sci.*, **11**, 1925), who has found in the spectrum of the companion to Sirius a displacement of the lines which would accord with the relativity displacement were the star of density of the order of 30,000 to 60,000 times that of water, as is required by Eddington's theory and by Seares' observations.

Calculations of the mean molecular weight and the adiabatics of matter in stellar interiors are made by R. H. Fowler and E. A. Guggenheim (*M.N.*, **85**, 939), who find the deviations from the gas laws important only in stars less massive than the Sun (see H. N. Russell on Eddington's theory above).

The correctness and interpretation of a theorem of v. Zeipel on a rotating star in radiative equilibrium is the subject of papers by J. H. Jeans (*M.N.*, **85**, 526), H. v. Zeipel (*M.N.*, **85**, 678), J. H. Jeans (*M.N.*, **85**, 934), A. S. Eddington (*Obs.*, **48**, 73), and B. P. Gerasimovic (*Obs.*, **48**, 148). In order to evade the seemingly impossible condition which v. Zeipel's theorem imposes on a star, circulating currents are proposed by the last two writers. H. Vogt (*A.N.*, 5342) considers the theorem in relation to K effect and motion in sun-spots.

G. Shajn compares (*A.N.*, 5394) the masses of the stars as deduced from Seares' equipartition theory and from Eddington's relation, and finds that the agreement is not good, especially for giants. Observations on double stars give, according to Seares' diagram, the greater mass to the fainter component.

H. Vogt considers the secular mass variation of the stars (*A.N.*, 5394).

B. P. Gerasimovic has investigated the radiative and mechanical equilibrium of spherical planetary nebulæ (*A.N.*, 5382).

Statistical Investigations.—In a general paper summarising our knowledge, F. H. Seares and P. J. van Rhijn (*Nature*, **115**, 948) give a new determination of the distribution of stars with respect to magnitude and galactic latitude. The suspicion that $\frac{dN(m)}{dm}$ for the brighter stars cannot be well represented by an error function is confirmed.

P. J. van Rhijn has published a corrected version of the number of stars between definite limits of proper motion, visual magnitude, and galactic latitude for each spectral class (*Pub. Kapt. Ast. Lab. Groningen*, **36**), using the whole of the Henry Draper Catalogue.

E. Öpik and Miss M. Lutsk find in a statistical discussion of irregularities of stellar distribution that absorption by obscuring clouds is probably the most important cause of dark gaps (*Pub. Obs. Tartu.*, **26**, 1924) (see also Fr. Becker, *A.N.*, 5347).

P. J. van Rhijn (*Groningen Pub.*, **37**, 1925) compares trigonometric, spectroscopic, and mean statistical parallaxes, which latter are considered substantially correct. Systematic corrections to spectroscopic parallaxes are tabulated. Young and Harper's results are specially considered. No trigonometric system, it is maintained, should be accepted unless it agrees with the mean parallax results derived from parallactic motion and from velocity components.

K. G. Malmquist comments on the parallax formula (*A.N.*, 5361).

G. Strömberg has investigated (*Astroph. J.*, **61**, 353) the radial

velocities of globular clusters and non-galactic nebulæ, and in *Astroph. J.*, **61**, 363, and *Proc. Nat. Acad. Sci.*, **11**, 365, he discusses the asymmetry in stellar motions as determined from radial velocities, and the general distribution of cosmical velocities.

F. H. Seares (*Astroph. J.*, **61**, 114) discusses the mean colour-index of stars of different apparent magnitudes down to the 17th, and the transformation of star counts to a grouping according to photographic magnitude from one according to visual magnitude, and vice versa. Variation with galactic latitude is given for mean magnitude 7·4, showing a galactic concentration of blue stars.

E. A. Kreiken discusses (*M.N.*, **85**, 499) the density function in the Milky Way, finding systematic dependency upon galactic longitude, and that in adjacent regions within a distance of 250 parsecs we may expect a ratio of 2 : 1 in space density. In *M.N.*, **85**, 985, he investigates the distribution of different spectral types along the Milky Way. The G- and F-type stars appear to be regularly distributed.

F. H. Seares and P. J. van Rhijn, in *Proc. Nat. Acad. Sci.*, **11**, 358, discuss the distribution of stars with respect to brightness and distance from the Milky Way.

W. J. Luyten contributes (*H.C.O. Circ.*, 273) a study of the brighter class M stars.

The motion, mean distance, and luminosity function of the O-type stars have been investigated by R. E. Wilson (*Astron. Journ.*, 841), and with W. J. Luyten (*Proc. Nat. Acad. Sci.*, **11**, 133) also the frequency distribution of apparent magnitude of the non-magellanic O-type stars.

W. J. Luyten discusses (*Proc. Nat. Acad. Sci.*, **11**, 87 and 130) the mathematical expression of the law of tangential velocities, and the calculation of mean absolute magnitude from apparent magnitude, proper motion, and radial velocity. In *Astroph. J.*, **62**, 8, he remarks on some problems connected with the Luminosity Law. There is, he finds, no marked gap between K-type giants and K-type dwarfs. A universal luminosity curve is improbable.

G. Prasad discusses the relation between mean absolute magnitude and mean linear cross velocity when stars are grouped in a manner designed by him to reduce accidental error (*M.N.*, **85**, 417).

Assuming a velocity distribution law in the stellar universe, the possibility of radial stream motions is shown by B. Lindblad to be explicable as due to encounters of stars with vast local accumulations of matter (*Astroph. J.*, **62**, 191).

Wave-Lengths.—A line possibly due to ionised lithium in stellar spectra is noted by O. Struve (*Astroph. J.*, **62**, 198).

P. W. Merrill writes on the infra-red oxygen triplet in stellar spectra (*P.A.S.P.*, **38**, 272).

F. E. Baxandall, in *Obs.*, **48**, 313, criticises some identifications by J. W. Nicholson, of lines in stellar spectra with the secondary spectrum of hydrogen, and concludes that there is no satisfactory evidence of any such lines in stellar spectra.

H. N. Russell has published in *Astroph. J.*, **61**, 223, a useful list of ultimate and penultimate lines of astrophysical interest.

Laboratory Spectra.—The electric furnace spectra of Va and Cr in the ultra-violet have been investigated by A. S. King (*Ap. J.*, **60**, 282).

Wave-lengths and pressure shift in the spectrum of magnesium are given by M. Petersen and J. B. Green (*Ap. J.*, **62**, 49).

The classification of certain p–p' groups in the spectra of Mg and related elements is discussed by J. B. Green and M. Petersen (*Ap. J.*, **60**, 301).

New regularities in the spectra of the alkaline earths are described by H. N. Russell and F. A. Saunders, who also discuss spectroscopic notation (*Ap. J.*, **61**, 38). An extension of the previously known spectrum of ionised calcium is published by these writers in *Ap. J.*, **62**, 1.

A. S. King describes the spectroscopic phenomena of the high current arc in *Astroph. J.*, **62**, 238.

The effects of high temperature ionisation have been studied experimentally by Sinclair Smith by means of electrically exploded wires (*Ap. J.*, **61**, 186).

Stark effect for H_β and H_ε $\lambda 4686$ has been studied by J. S. Foster (*Ap. J.*, **62**, 229).

O. S. Duffendack writes on the energy levels in band spectra in *Ap. J.*, **61**, 209.

An analysis of the secondary spectrum of hydrogen has been undertaken by J. W. Nicholson (*M.N.*, **85**, 449), who finds it very complicated, and consisting of lines due to H_2, H_2^+, H_3, and H^-. In *M.N.*, **85**, 656, he describes a hydrogen spectrum of constant frequency difference, into which type of series the greater part of the strong lines in the spectrum fall (apart from the Fulcher and other bands given in the first paper).

Miscellaneous.—In a special study of the Cepheid problem (*Pub. Dom. Obs. Ottawa*, **9**, 1 (1925)), F. Henroteau concludes that the ordinary binary theory may almost certainly be ruled out of court, while on the pulsation theory there are certain points unexplained. Shapley's period-luminosity law is to be regarded as a curve of statistical averages, and the true relation should involve colour-index as well. Other papers on Cepheids are those of J. Hellerich (*A.N.*, 5369), and C. Hoffmeister (*A.N.*, 5388), and F. Henroteau (*Journ. R.A.S. Can.*, 1925), in which last the variation of ionisation in the atmospheres of Cepheids is discussed.

The existence of penetrating radiations is considered as established by R. A. Millikan (*Nature*, **116**, 823), who places their source outside the earth. J. H. Jeans discusses the mechanism of their generation (*Nature*, **116**, 861), and estimates that the high-frequency radiation from the Andromeda nebula would suffice to account for about half the observed effects. These rays, he finds, provide an explanation of the luminosity of nebulæ and of the maintenance of the earth's negative charge.

In a review of work on the Magellanic clouds and the period luminosity law (*Scientia*, August 1925) Shapley considers that the clouds give evidence definitely against a short-time scale for the universe.

Fr. Becker writes on cosmic clouds in the region of V and UW Draconis (*A.N.*, 5359).

The absolute brightness of dwarf stars is found by W. Rabe to be a function of their temperature and mass (*A.N.*, 5389).

F. G. Pease finds (*P.A.S.P.*, **36**, 89) the diameter of o Ceti at the 1925 maximum to have been of the same order as that of Betelgeuse.

Miss C. H. Payne, in discussing the astrophysical data bearing on the relative abundance of the elements, finds (*Proc. Nat. Acad. Sci.*, **11**, 192) that there is a general rough correspondence with the terrestrial distribution.

The first of a series of monographs to be issued from Harvard has appeared in a very useful book by Miss C. H. Payne on *Stellar Atmospheres* (*H.O. Monographs*, No. **1**), which deals with the theory and observational study of high temperature ionisation effects in the reversing layers.

Two general works on Astrophysics have been published during the year. *Modern Astrophysics*, by H. Dingle, is a popular but comprehensive study, and *Astronomical Physics*, by F. J. M. Stratton, is an introductory course for students. J. A. C.

Double Stars.

Measures and New Pairs.—The largest set of measures published during the past year is that of van den Bos, made with the 10½-inch refractor at Leiden during the years 1920–25 (*Annals*, **14**, part 3). There are in all about 3000 measures of 700 double stars, many of which have a separation under 1″. The errors, accidental and systematic, to which the observations are subject are carefully discussed. The method of using a reversing prism in the way recommended by Salet and Bosler, *i.e.* with and without prism, is found most satisfactory and strongly recommended for stars sufficiently bright to be seen with a prism. Dr. van den Bos has also published a dissertation, in Dutch, on his double-star work.

During the year we have received from Pulkowa vol. **7**, part 4, and vol. **9**, part 1, of their publications containing double-star observations, made mostly with the 15-inch refractor. The earlier part contains measures of 154 double stars, mostly Σ, measured by B. Seraphimow up to 1900, the latter 577 measures of 215 Σ and OΣ stars measured by G. Neujmin in 1911 and 1912.

The following table indicates lists of observations in various astronomical periodicals :—

Author.	Reference.	No. of Stars.	Selection.
Bower, E. C.	*A.J.*, 851	1	70 Ophiuchi.
Doberck, W.	*A.N.*, **224**, 81	108	Misc.
,,	*A.N.*, **225**, 337	145	,,
Espin, T. E.	*M.N.*, **86**, 79	41	Holmes' stars.
Espin and Milburn, W.	*M.N.*, **85**, 276	41	Misc.
		113	New.
Ellison, M. A.	*M.N.*, **85**, 1021	32	Bright Σ.

Author.	Reference.	No. of Stars.	Selection.
Labitzke, P.	*A.N.*, **224**, 197	116	Misc.
Leavenworth, F. P.	*A.J.*, 854	59	,,
Luplau-Janssen, C.	*A.N.*, **223**, 165	27	,,
,, ,,	*A.N.*, **225**, 261	32	,,
Olivier, C. P.	*A.J.*, 846	100	Recently discovered.
Phillips, T. E. R.	*M.N.*, **86**, 77	63	Bright Σ.
Van den Bos	*B.A.N.*, 74	27	
Zosé (Observatory)	*A.J.*, 849	128	Misc.

The only new pairs for which data have been published during the year are those of Espin and Milburn included in the above table. They are Es 2079–2137 (59 stars) and M 323–376 (54 stars), of which 42 and 39 respectively have a separation under 5″. The measures of van den Bos are photographic : the minimum separation is 4″·2.

Orbits.—Three new orbits have been published during the year :—

	P.	*a.*	*e.*	
Krüger 60	44·3 years	2″·46	0·38	R. G. Aitken, *P.A.S.P.*, **37**, 222.
β 581	44·0 ,,	0·45	0·39	,, *Lick Bull.*, 365.
Σ 1037	120·4 ,,	0·87	0·93	G. van Biesbroeck, *M.N.*, **85**, 478.

Attention is drawn to the large eccentricity of Σ 1037.

In *A.N.*, **223**, 335, J. Hellerich has discussed the differential corrections to the elements of an orbit.

Miscellaneous.—In *A.N.*, **226**, 49, G. Shajn gives the results of observations, for the determination of the colour equivalents of double stars, made with the astrographic telescope at Pulkowa. Fifty pairs were observed with an objective grating, but these results are not yet published. It was then found better to use Seares' method of exposure ratios. The stars were mostly observed at two or three epochs. In order to get fully exposed images with a sensible diameter, the minimum separation had to be taken at 3″·5. Of the 123 double stars for which results are published, 47 are of unknown spectrum. The results are discussed to show the relation between colour and spectrum and also in connection with the giant and dwarf theory of evolution, and it is found that the absolute magnitudes fit into Russell's scheme.

In *Ap. J.*, **62**, 104, the same writer discusses the accuracy of spectroscopic parallaxes, utilising the fact that for double stars forming physical systems the difference of the absolute magnitudes of the components equals the difference of the apparent magnitudes. For later spectral types he finds that the probable error of the parallaxes is of the order of 20 per cent. of the parallax, while for A- and B-type stars it is about 70 per cent. of the parallax. The correlation between spectral type and absolute magnitude for the A and B stars, which is evident for stars in moving clusters, is much less evident for individual stars of known trigonometric parallax. These early-type stars are found to have a considerable dispersion in absolute magnitude.

In *M.N.*, **85**, 245, Shajn considers the mass ratio of double stars in

connection with the evolution of stars, deducing the mass ratio for 342 systems on the basis of Eddington's theory of radiative equilibrium.

H. L. Alden, in *A.J.*, 851, employs parallax plates to investigate the orbit of the spectroscopic binary μ Persei. From the spectroscopic observations it is found that $a \sin i = 8 \times 10^7$ km. $= 0{\cdot}535\pi$ where π is the parallax. Using the values of P, T, e, ω found from the spectroscopic observations, the measures of the parallax plate are used to deduce the other elements of the orbit and also the parallax. It is found that $\pi = 0''{\cdot}030$, $a = 0''{\cdot}019$, $i = 74°$. The agreement with the above relation is close. Alden finds in a similar way that for Algol $a = 0''{\cdot}0518$, $i = 57°{\cdot}9$ (*Pop. Ast.*, **33**, 163). The distribution of mass between the two faint components of o Eridani and Krüger 60 is given in *Pop. Ast.*, **33**, 164.

G. van Biesbroeck summarises the result of his observations of 1300 Hussey stars in *Pop. Ast.*, **33**, 305. In an interval of roughly twenty years he finds that 2 per cent. show curvature of path, 17 per cent. orbital motion, 14 per cent. a common proper motion, 63 per cent. no certain change, 3 per cent. change of uncertain nature, and that 1 per cent. are only optical double stars.

Southern Hemisphere.—Dr. van den Bos, of Leiden Observatory, has proceeded to the Union Observatory, Johannesburg, to make double-star observations with the new 26-inch refractor. For an account of the work there, and of the progress with the New Reference Catalogue of Southern Double Stars, see the report of the Union Observatory on p. 208. The work at Johannesburg, together with that at Bloemfontein with the Lamont telescope, and by Dawson at La Plata, should soon greatly improve our knowledge of southern double stars. J. J.

Variable Stars.

A large amount of work on variable stars has been done during the year both of a routine and an original character. Work of the former kind, including records and analyses of observations of known variables and discovery of new ones, is not referred to here unless it shows features of special interest.

The valuable report of the Commission on Variable Stars, contained in the *Transactions of the International Astronomical Union*, Cambridge Meeting, 1925, calls for particular mention. It contains matter of interest and importance in connection with all types of variables.

The discovery of Nova Pictoris on May 25 was followed by a number of papers reporting the results of observations of the nova and conclusions based thereon. The more important of these are *Observatory*, **48**, 261; *Harv. Bull.*, Nos. 821 *et seq.*; *P.A.S.P.*, **37**, 235. A remarkable feature of the phenomenon was the very slow rise to maximum, covering a period of 15 days. The spectrum remained fairly constant (A type) during the rise to maximum, but underwent complex changes thereafter, of the same general type as those usually associated with novæ, but in detail deviating somewhat from the typical spectral progression.

These facts are discussed by J. Hartmann (*A.N.*, 5413) in their bearing on the problem of the origin of novæ. Assuming Nova Pictoris to be a typical object in this respect, he considers that the constancy of spectrum during a prolonged rise to maximum rules out Seeliger's assumption of a collision between a star and a cosmic cloud, and, *a fortiori*, the hypothesis of a collision between two stars or a star and a planet. Hence the cause of outburst must lie within the star, and is to be regarded as a disturbance of physico-chemical equilibrium which comes about automatically at a certain stage of development. The author supports the view of Lundmark and Barabascheff that the disturbance has the character of a radio-active atomic change. Assuming the change to take place at the centre of the star, where the temperature and pressure are highest, and then to spread outwards, a sudden expansion of the star would ensue without change of temperature of the surface layers. Hence the brightening is due to increased surface area alone. When the disturbance reaches the surface, the brightness reaches a maximum and thereafter decreases through cooling or contraction of the star. It is at this stage that the typical nova spectrum appears. The subsequent characteristics of the light-curve are attributed to a pulsation of the star set up by the disturbance. Since the brightening is assigned entirely to change of surface area, the observed magnitude and radial velocity changes (the latter are assumed to be due entirely to radial expansion, the star as a whole remaining stationary with respect to the earth) provide sufficient data for calculating the diameter of the star, which comes to 141 million km. shortly after the beginning of the outburst. From the known surface brightness of A-type stars the parallax is then calculated as 0″·0007.

N. Barabascheff (*A.N.*, 5365) considers the observed changes of apparent diameter of Nova Aquilæ (1918) in the light of his pulsation theory of novæ (see *A.N.*, 5327). He shows that the changes to be expected from the theory closely accord with the measured values given by Aitken. With this result as a justification, he calculates, from theoretical considerations and the observed angular diameters, the parallaxes of this star, Nova Lacertæ (1910), and Nova Geminorum (1912). The values obtained are respectively 0″·0019, 0″·0036, 0″·0055.

Harv. Bull., 814, gives particulars of S. Doradus, a 9th magnitude variable in the open cluster N.G.C. 1910 (situated in the larger Magellanic Cloud), which is probably the most luminous star known. Its median absolute magnitude is −8·9. The radiation is equivalent to that of nearly 600,000 stars of the Sun's luminosity, and corresponds to a loss of mass of 2½ million million tons per second. The spectrum is of P Cygni type, and the star appears to be associated with nebulosity. The variation is irregular, with a range of 1·5 mag. The diameter of the star is probably less than that of the red super-giants in the cloud, but easily exceeds that of the earth's orbit.

La Rosa's ballistic theory of variable stars is criticised by C. Nordmann and C. le Morvan in *C.R.* **180**, 1159, on the ground that it requires that the amplitude of variation should be the same for all regions of the spectrum. La Rosa discusses the criticism in *N. Cimento*, **2**, 159, and in *A.N.*, 5350, he replies to the objection of de Sitter that the theory

requires that a star should "in a part of its orbit have three different velocities at the same time."

In *M.N.*, **85**, 484, Miss M. A. Blagg reduces 1500 observations of β Lyræ made by four members of the B.A.A. The observations extend over 16 years and represent more than 400 periods.

The diameter of Mira has been measured by F. G. Pease with the interferometer, and found to be of the same order as that of Betelgeuse (*P.A.S.P.*, **37**, 89).

A difficulty arising in the calculation of the orbits of eclipsing variables from spectroscopic observations is discussed by J. Hellerich in *A.N.*, 5351. Previous investigations had revealed differences in the times of conjunction of the components when calculated from spectroscopic and photometric data, respectively. It was thought that these might be due to rotation of the components, resulting in an apparent displacement of spectrum lines when part of a component is eclipsed. The suspicion was tested by rejecting all spectroscopic observations made during eclipses and calculating circular orbits from the remaining observations. The procedure is strictly valid only when the subsidiary minima are symmetrically situated with respect to the chief minima, but the errors in other instances are stated to be negligible. The times of conjunction given by orbits so calculated agree with the photometrically-determined values in nearly all the cases examined (14 in number) within the limits of observational error. The suspicion is thus confirmed.

By far the greatest amount of work of the year has been concerned with the Cepheid problem. Its general character indicates a pronounced tendency to revert to a binary star explanation of the phenomenon, with which several investigators combine the hypothesis of a pulsation of the chief component. This suggestion of a dual cause has arisen from considerations of both eclipsing binaries and typical Cepheids, and in one instance an apparently irregular variable, with a larger range of variation than is usual in such stars, is suspected by E. Hertzsprung (*B.A.N.*, II., No. 77) of being an eclipsing binary of which one component possesses a variation of another kind.

J. G. Hagen (*A.N.*, 5386) protests against the assumption, particularly noticeable in American and English publications, that a binary star explanation of Cepheids is untenable. He considers that the phenomenon is inexplicable without the assumption of a binary star, and that the final explanation will include pulsation also.

In a second part of the paper referred to above (*A.N.*, 5351), J. Hellerich discusses anomalies which appear in the light-curves of eclipsing variables. These are of two kinds: (1) ascending branch during eclipse steeper than descending branch; (2) brightness at end of eclipse greater than at beginning, the minimum being symmetrically placed. A second cause of variation, superimposed on that due to eclipse, is indicated, but, owing to its small amplitude, it is impossible to isolate it. It must have, however, the same period as the orbital revolution, and it may be described by saying that the brightness of the system in the interval between the chief conjunction and the ascending node of the orbit of the brighter component is greater than in the other parts

of the orbit. Now in Cepheids a similar relation is found, the light-maximum taking place shortly before the ascending node of the brighter component, and it is suggested that the superimposed variation in eclipsing binaries has the Cepheid character. Spectral changes are associated with the anomalies, which are related to the spectral properties of Cepheids. In the stars considered, the hypothetical Cepheid variation is much smaller in amplitude than the eclipse variation, but Guthnick (*Veröff. Berlin Babelsberg*, Bd. 2, Heft 3, p. 53) has found a similar phenomenon in certain spectroscopic binaries which is attributable to a combination of Cepheid and eclipse variations of the same order of magnitude. The close relation between the two types of variation shows that a simple pulsation of the component stars is an insufficient explanation of the Cepheid type in binary stars. Guthnick suggests a non-uniform distribution of brightness over the stellar surface. If this is the true explanation, then the identity of the brightness distribution with respect to orbit in different stars shows that the non-uniformity must be due to an interaction between the two components or between each component and the orbital motion. In the first case, tides, and in the second, motion in a surrounding medium, are suggested. These possibilities are discussed, and the latter (*i.e.* Duncan's hypothesis) is regarded as the more probable.

The question whether all Cepheid variation is of this character is discussed by the same writer in *A.N.*, 5369. The hypothesis is advanced that Cepheids are close double stars with a physical variation in the brighter. The brightness ratio of the stars is large, but the fainter component, though it may be much less massive than its companion, is not necessarily smaller in dimensions. The δ Cephei and ζ Geminorum types are regarded as identical in character, but as having different amplitudes of eclipse variation ; the amplitude is large in δ Cephei and small in ζ Geminorum. (All variables of ζ Geminorum type that have been adequately examined are said to show an irregularity in the ascending branch of the light-curve.) The difference can be accounted for by a difference in the dimensions-ratio of the components, a difference in orbit inclination, or a difference in separation of components. Eclipsing variables and Cepheids, on the other hand, differ only in the relative amplitudes of the physical and eclipse variations, and δ Cephei and RR Lyræ variables are distinguished by the much larger ratio of radii of the components in the latter. The case of a circular orbit with spherical components in contact at the surfaces is considered, and is shown to reproduce the light-curve of δ Cephei as closely as could be expected. Motion in a surrounding medium is suggested as the cause of the physical variation, but, whatever hypothesis is adopted, the limitation of the variation to certain spectral classes must be regarded as being bound up with the course of evolution of the stars ; the closeness of the components demands an early stage. The arguments against a double-star hypothesis for Cepheids are considered and countered ; the spectral changes of the stars, for example, are attributed to the eclipses, both components being assumed capable of contributing to the spectrum. The hypothesis is shown to explain the period-luminosity law.

C. Hoffmeister (*A.N.*, 5388) discusses the light-curves of Cepheids

statistically. He finds that the curves can be characterised uniquely by the function $C=4G_a\frac{M-m}{P}$, where G_a is the absolute term of the Fourier series representing a curve, M and m are the magnitudes at maximum and minimum, and P is the period. The curves being drawn so that the period of each is represented by the same horizontal length, values of C are calculated for 122 stars and found to range approximately from 10 for ζ Geminorum variables to 1 for antalgols (RR Lyræ type). Sixty-nine per cent. of the stars have curves showing the presence of a secondary periodic variation, which affects the main curve in various ways, of which three predominate : (1) depression in ascending branch ; (2) elevation in descending branch shortly after maximum ; (3) irregularity near minimum, immediately before beginning of ascent. The first kind of variation is specially interesting because it occurs at the place where an eclipse minimum would be expected if the stars were binaries. The 19 stars affected by it are mainly stars of longer period. Variation (3) characterises mainly the antalgol stars, but reasons are given for considering it as identical in character with variation (1). As the amplitude of the main variation decreases from star to star, that of the secondary variation decreases also, but at a much slower rate, so that the main and secondary variations are probably due to distinct causes, which are not, however, altogether independent; thus the probability of an eclipse is heightened. Hellerich (see above) suggests that the bright component of a Cepheid is a variable with a large dark companion close to it. The phenomena considered here suggest that the companion is small and far removed from the primary. No great weight, however, is attached to the discrepancy in view of the inexact character of the light-curves. The relations between C and the various characteristics of the stars are discussed. It is concluded that while the origin of Cepheid variation is the same in stars of long and short period, yet these two classes differ greatly in cosmic significance. Evidence is given of identity of character between the antalgol stars and the cluster variables.

Another view of Cepheids which combines pulsation with duplicity of the stars is put forward by J. H. Jeans (*M.N.*, **85**, 797). Jeans's theory arises from an investigation of the process of fission of stars. Considerations of the physical condition of stars, based on certain hypotheses, lead to the equation, $\log T_e=2{\cdot}5\log E-11{\cdot}75\log(\theta M)+a\ constant$, where T_e and M are the effective temperature and mass of the star respectively, E is the rate of generation of energy in the star's interior, and θ is a function of M which varies slowly with M. It is assumed that when fission takes place, M and E are conserved, and this implies that T_e must be considerably greater for the products of fission than for the original star. There is therefore a comparatively sudden change of spectrum to a much earlier type. Taking the characteristics of the known binary stars, and working backwards to their state before fission, it appears that the course followed by them with respect to spectral type and other characteristics, is represented at its various stages, among existing stars, by irregular, long-period and Cepheid variables. It is therefore suggested that these variables are stars in

the act of fission. At the beginning of fission there is a rotation and an oscillation, and the periods of the two are different and, in general, incommensurable. This corresponds to irregular variation. As the process goes on there is a continuous tendency to equality of the periods, and the star passes successively through the conditions of long-period and Cepheid variables to an ordinary binary star. At every stage of the process at which a definite periodicity is shown, the periodicity is that of the star's rotation. Reasons are given for rejecting simple pulsation as a possible cause of Cepheid variation. The following table shows the suggested sequence of changes.

Shape of Star.	Class of Star.	Light-Curve.	Spectrum.	Range.
Ellipsoid	Unobserved	..	Dark	..
Pear-shaped	Irregular variable	Periods superposed	M, N	Up to 6 m.
,,	Long-period variable	Traces of irregularity.	M	Up to 6 m.
,,	Cepheid	Regular periodicity	M to A	0·4 to 1·0 m.
Two ellipsoids	Early spectroscopic and eclipsing binaries.	Orbital periodicity	A, B	Up to 0·7 m.

The hypothesis is shown to give a satisfactory explanation of the period-luminosity relation for Cepheids and to require a light-curve of the observed form. A period-luminosity relation for long-period variables also is suggested.

Two investigations of particular stars show the same tendency towards the assumption of a dual cause of variation. J. Schilt (*B.A.N.*, III., No. 83) discusses observations of the eclipsing binary, RZ Tauri, which suggest the existence of a physical change in one or both of the stars. Fr. Becker (*A.N.*, 5377), in a discussion of data for η Aquilæ covering the period 1895–1925, shows that variations of an apparently irregular character occur in the magnitudes at maximum and minimum and in the amplitude of variation. An irregularity in the descending branch of the curve indicates the influence of a variation other than the main one.

Several valuable investigations of Cepheid variation which are, in the main, independent of theoretical considerations have been made during the year. At the Observatory of the University of Michigan a new method of investigating the Doppler line displacements of these stars has been developed, and is presented in a number of papers by R. H. Curtiss, W. C. Rufus, and J. A. Aldrich. (For the most important papers, see *Proc. Nat. Acad. Sci.*, **10**, No. 6, p. 264; *Pop. Ast.*, **32**, 471, 547.) The lines are classified with regard to level in the atmosphere on the basis of the solar studies of St. John and Mitchell, and the difference in displacement of lines originating at different levels is attributed to a variation of radial velocity with height in the atmosphere. Atmospheric compressions and rarefactions are thus deduced and correlated with the light variations and spectrum changes of the stars. It appears that there is a lag of phase of the upper layers with respect to the lower. If the cause of variation is attributed to pulsations, the conclusion seems unavoidable that the pulsations must originate below the effective

radiating layers and be communicated first to the lowest of the overlying absorbing layers and then upwards to the highest. It is suggested that the ordinary velocity curve of a Cephcid is not definite, and that the " elements of an orbit " depend upon the selection of lines. The stars chosen for special examination are S Sagittæ and η Aquilæ.

F. Henroteau (*Pub. Dom. Obs., Ottawa*, IX., Astrophysics, No. 3) attempts to apply this method of investigation to ζ Geminorum, but finds no differences in the radial velocities indicated by the lines measured. In the same paper the degree of ionisation in the atmosphere of the star is estimated from the relative intensities of the neighbouring spectrum lines, 4534·14 (Ti^+) and 4534·95 (Ti). These lines appear to be very sensitive to physical changes, and the ratio of their intensities changes continuously throughout the period of variation. Minimum ionisation occurs at about $\frac{1}{4}$-period after maximum light, and maximum ionisation at about $\frac{1}{4}$-period before maximum light.

This method of estimating the degree of ionisation in the atmospheres of stars is applied by Henroteau (*Journ. Roy. Ast. Soc. Canada*, **19**, 81) to other Cepheids also. α Ursæ Min. shows similar characteristics to ζ Geminorum, but in δ Cephei and η Aquilæ, on the other hand, there is a minimum of ionisation at minimum light, and a maximum of ionisation at maximum light. The ionisation decreases much more rapidly after maximum in these stars than in ζ Geminorum and α Ursæ Min. These facts point to a distinction between the ζ Geminorum and δ Cephei types of variables.

A statistical method of treating the same problem is presented by A. Pannekoek and J. J. M. Reesinck in *B.A.N.*, III., No. 87. The intensities of the spectrum lines are assumed to be functions of two parameters, T (effective temperature) and g/k (g=gravity ; k=coefficient of absorption of surface layers). Fifteen stars (including three Cepheids, viz. δ Cephei, ζ Geminorum, α Ursæ Min.) are selected, and the intensities (estimated on an arbitrary scale) of 150 spectrum lines are recorded for each star. The lines are classified with respect to character as *a*, *ae*, *e* (*a*=arc ; *e*=enhanced), and with respect to temperature as HHH, HH, H, M, L, LL (H=high ; M=medium ; L=low). Details of the method of classification are given in *B.A.N.*, No. 79. The mean intensity of each line is then computed for the whole group of stars, and the deviation, x, from this mean, for each line in each star, is expressed as a linear function of a temperature co-ordinate, p, and a gravity co-ordinate, q ; thus, $x=ap+bq+r$. a and b are assigned numerical values depending on the character of the line considered. The equations are solved by the method of least squares, and values of p and q are obtained for each star. It is then assumed that the quantities, $\log g$ and c_2/T, are linear functions of p and q, and the numerical constants in the expressions for these functions are determined by least squares, taking Hertzsprung's values for c_2/T, and for g the values calculated for the binaries, of which the selected stars include nine. The values of T and g for individual stars are thus found. In the case of the three Cepheids the calculation is made at different phases. It appears that the temperature of each Cepheid is lower at minimum than at maximum, and that the variation of temperature affects not only the hydrogen lines but the other lines

also, both arc and enhanced. The temperature of ζ Geminorum is found to be definitely lower than that of δ Cephei—a conclusion at variance with the result of Adams and Joy, but in accordance with Shapley's rule that the spectrum becomes more advanced with increasing period. The results for g are much more difficult and uncertain. It appears, however, that the mass of δ Cephei given by Eddington's mass-luminosity relation is too high. A large mass, which Eddington's relation requires, is highly improbable for Cepheids, and "there is some probability that their masses are even smaller than the sun's mass." It is admitted that the assumptions underlying the formulæ used may not be fulfilled in pulsating stars, but general reasons are given for believing that an explanation of the discordance in this way is not probable. Similar conclusions are arrived at for ζ Geminorum and α Ursæ Min.

In *Pub. Dom. Obs. Ottawa*, IX., Astrophysics, No. 1, F. Henroteau gives a general résumé of the characteristics of Cepheids, together with useful tabulated data. Under the heading of "Cepheids" are discussed stars of the following types :—

(1) δ Cephei.
(2) ζ Geminorum.
(3) Cumulids.
    (A) Antalgols.
    (B) Cluster variables.
(4) β Canis Maj.
(5) α Orionis.

Radial velocity and other data are given and discussed separately for δ Ceti, τ Cygni, β Cephei, 15 Canis Maj., α Ursæ Min., δ Cephei, and γ Ursæ Min. Photographic light-curves, obtained by the method of comparing the image of the variable with the images of a number of stars whose photographic magnitudes have been accurately determined ("nothing else than Argelander's method applied by him directly to the determination of photometric magnitudes, but here applied to the photographic plate"), are then given for X Cygni, SZ Cygni, TX Cygni, UY Cygni, VX Cygni, VY Cygni, WZ Cygni, and XZ Cygni. It is concluded that the present state of our knowledge of Cepheid variation is scarcely adequate to explain all the phenomena involved. Ordinary binary theories may almost certainly be ruled out of court, while on the pulsation theory there are certain points not accounted for. It is regarded as at least plausible to suppose that short-period variables of the β Canis Maj. and allied types should be considered as forming part of the same sequence as true Cepheids. They show peculiarities (such as variation of amplitude and of centre-of-mass velocity) which appear definitely to indicate the presence of a satellite and which cannot be satisfactorily explained on the assumption of simple pulsation alone. Similar fluctuations are suspected in some of the true Cepheids. The conclusion is drawn from certain adduced facts that Shapley's period-luminosity relation should perhaps be regarded more or less as a curve of statistical averages, and that the true relation, applicable to particular cases, should involve colour-index as well.

G. Zacharov (*A.N.*, 5384) records a series of photometric observations of RR Lyræ, and deduces a period and light-curve. Comparison with the visual observations of previous workers shows that the phase of the variation of visual light is not synchronous with that of ultra-violet light. This has been found for other stars, but whereas in most instances there is a relative retardation of the ultra-violet light-curve, the reverse occurs in RR Lyræ. H. D.

Nebulæ.

Since last year's note on Nebulæ was written, details have been published of the very important work on Cepheid variables found in certain spiral nebulæ by Hubble (*Observatory*, **48**, 139). The two principal spirals investigated were the Andromeda Nebula (M 31) and M 33. Both these objects yielded similar results. In M 31 the outlying regions, long known to yield a granular appearance in photographs, were made the subject of special work with the 100-inch reflector. These outer regions, which are quite different in appearance from the amorphous nuclear regions, were found to consist to a large extent of faint stars up to the 20th magnitude. It was amongst these faint stars that the Cepheid variables were found. The plane of the nebula is inclined to the tangent to the celestial sphere at an angle of about 65°, and there are areas of presumably dark matter in the vicinity as well as some general luminosity which is shown in longer exposures with smaller reflectors. The long and arduous work of investigating the period-luminosity relationship was rewarded by the discovery of 12 Cepheids in these outer regions of the nebula. The apparent magnitude of these variables was between 18th and 19th, which gave a distance scale of approximately 285,000 parsecs., or 930,000 light years. The great majority of the Cepheids were of long period, from 18 to 50 days, the short period " cluster " variables of a few hours' period being entirely absent. It is possible to explain this fact, which at first sight seems anomalous, as the result of the period-luminosity relationship, which gives the short-period Cepheids as two magnitudes fainter than the longer ones, and therefore probably too faint to be shown by the exposures given.

The spiral M 33 is a much more condensed nebula than M 31, and in the outer regions consists almost entirely of stellar points. The conclusion that these points were probably stars was drawn years ago. The results in this case were even more definite than in the case of M 31, but with magnitudes of the same order. The inference is that M 33 (which is only a little more than half the angular diameter of M 31) is at approximately the same distance.

Other spirals of smaller angular dimensions are under examination by Hubble at the present time, and it is to be hoped that these investigations will give us some idea of their comparative distance and dimensions.

Papers have been published from the Vatican Observatory in recent years in which Father Hagen seeks to establish the existence of " dark "

obscuring nebulæ in regions of the sky far removed from the galactic equator. More recently an analysis of the counts of about 250,000 stars by Miss Lukk at Tartu of Paris Astrographic charts has led Öpik to the conclusion that a vast amount of obscuration seriously affects the distribution of faint stars, and Wirtz calls attention to the high correlation between Hagen's dark nebulæ and the star vacancies revealed by the Tartu investigation. If established, the existence of such areas of obscuration in high as well as low galactic latitudes must seriously modify past work on faint stars, spiral nebulæ, and globular clusters, and Shapley in H.C.A. Circular 281 gives an account of a further examination of the question. The limiting magnitude of the Paris charts is 14·5 photographic, and the results of Miss Lukk's work were confirmed up to this limit, showing localised vacancies and clusterings of stars much greater than a random distribution would yield.

Twenty-two plates of longer exposures with the 24-inch and 16-inch refractors were obtained for comparison with the Paris charts. These plates showed stars from one to three magnitudes fainter than the charts, and it was found that all the clusterings and all but four of 28 obscurations disappear if the fainter stars are taken into consideration. The four established obscurations are in regions in Taurus and Vulpecula, where the presence of dark nebulæ was already known. The conclusion is drawn that Hagen's dark nebulæ are to be explained not as obscurations but as the effect of uneven distribution of stars brighter than the fifteenth magnitude.

In *M.N.*, **85**, 865, Lundmark discusses the motions and distances of spiral nebulæ by direct and indirect methods. He points out that no reliable direct parallax measures have been obtained, and the same may be said for proper motions. Radial motions, if interpreted as a normal Döppler effect, show a certain correlation with angular size, the smaller being the more rapid, especially those near the North Galactic Pole, and these, combined with as large a limiting proper motion as 0″·01, give a minimum distance of 30,000 light years. Plates of M 33, measured originally by Van Maanen, were remeasured by Lundmark with very different results, the rotation period of this spiral being found to be over ten times that given by Van Maanen. The chief indirect method employed was the comparison of novæ found in spirals with galactic novæ, on the assumption that they are directly comparable with regard to absolute magnitude. A discussion of the absolute magnitude of novæ leads to the conclusion that the Andromeda Nebula is distant 1,400,000 light years, which is somewhat greater than Hubble's estimate. Lundmark also discusses a nova in the globular nebula *N.G.C.* 4486, which reached a maximum of 11·5 mag., and the conclusion is that this object is 8,000,000 light years distant. We may hesitate to accept this distance and the 56,000,000 light years for *N.G.C.* 4594 until we get more definite evidence. The statement that " the so-called nebulous background in the spiral arms is, as a rule, certainly not nebulosity, but the light from numerous stars apparently gathered together on account of the vast distances from which they are seen," is also open to argument.

In *M.N.*, **85**, 535, there appears a paper by H. Groot " On the True

Shape of some Spiral Nebulæ." Following von Pahlen's method, a certain number of spirals are investigated, and these are found, with one exception, to be of the equiangular spiral form—agreeing with von Pahlen's earlier conclusions. Groot also contributes another paper on the same subject in *M.N.*, **86**, 146. In this paper the nebulæ mentioned in the text as G 21 and G 52 are N.G.C. 2841 and 7331 respectively.

In *M.N.*, **85**, 1014, Reynolds discusses the general development of the spiral form in nebulæ of this class, and after examining examples of spirals with arms extending from half a revolution to two revolutions, considers that the equiangular form is only represented in the early stages of development. In spirals developed much over one revolution, the bifurcations and arms become completely irregular, and ultimately, when two revolutions have been accomplished, show a marked tendency towards breaking up altogether. Spirals of less than half a revolution and more than two revolutions are almost unknown.

On the theoretical side, Jeans contributes a " Note on the Distances and Structure of the Spiral Nebulæ." In *M.N.*, **85**, 534, corrections to previous estimates are given, based on recent observational work by Hubble and others. From various data the inference is drawn that the Andromeda Nebula nucleus is 5×10^{42} grammes in mass, or about 2500 million suns, and thus comparable to the estimated total mass of our galactic system. Adopting this mass, the distribution would be at the rate of 1 gramme per sq. cm. of cross-section in the line of sight. With such a value for the optical thickness, the nebula would be almost entirely transparent if composed wholly of gas, or of solids of dimensions of several centimetres, or of the two combined.

Gerasimovic in a paper " On the Radiative and Mechanical Equilibrium of the Spherical Planetary Nebulæ " (*Ast. Nach.* 225, 5382) criticises a conclusion reached by Milne on the same subject (*M.N.*, **85**, 139). Both have shown that if a planetary nebula is a detached shell supported by radiation pressure, the coefficient of absorption must decrease through the thickness of the nebular shell outwards from the central star, as radiation pressure must exceed gravity at the internal face and be less than gravity at the external face. Milne replies in the *Observatory*, No. 617, 317, and agrees with Gerasimovic that his previous conclusion, *i.e.* that the existence of such a detached envelope supported by radiation pressure is unlikely, is an overstatement of what he had established. A great deal obviously depends on the chemical composition of the shell, and the actual composition is known to be much more complex and consists of lighter elements than Milne's hypothetical shell of ionised calcium. He finds, however, that there are still theoretical difficulties in the way of accepting the hypothesis. A reply by Gerasimovic appears in the *Observatory*, No. 619.

J. H. R.

List of Public Institutions and of Persons who have contributed to the Library, etc., since the last Anniversary.

(*Institutions exchanging publications with the R.A.S. Library are omitted from this list, in order to economise in printing.*)

Amsterdam, Société Hollandaise des Sciences.
Barcelona, Observatorio Fabra.
Barcelona, Reale Academia de Ciencias y Artes.
Bern, Schweizerischen Geodätischen Kommission.
Bordeaux, Société Astronomique.
Buenos Aires, Instituto Geografico Militar.
Canada, Geodetic Survey.
Cape Town, Astronomical Society of South Africa.
Cartuja (Granada), Estación Sismológica.
Chaldean Society.
Fundacío concepcío Rabell i Cibils vídua Romaguera.
Geneva, Société Astronomique Flammarion.
Hamburg, Deutsche Seewarte.
India, Meteorological Department.
Kiel, Sternwarte.
Kobe, Imperial Marine Observatory.
Kyoto, Society of Friends.
Kyoto, University Observatory.
Lemberg (Lwów), Observatorium der Technischen Hochschule.
Leningrad, Société Astronomique de Russie.
Liverpool, Astronomical Society.
London, Chemical Society.
Louvain, Université Laboratoire d'Astronomie et de Géodésie.
Mauritius, Royal Alfred Observatory.
Mount Wilson Observatory.
Roumania, Observers' Association.
Tokyo, Imperial University.
Tokyo, Institute of Physical and Chemical Research.
Tokyo, National Research Council of Japan.
Toulouse, Académie des Sciences, Inscriptions et Belles-Lettres.
Trieste, Regio Osservatorio Astronomico.
Tübingen, Observatory.
Warsaw, Université Libre de Pologne, Bureau Astronomique.

Signor P. G. Alfani.
Prof. T. Arendt.
Dr. J. Bauschinger.
Verlag C. H. Beck.
Herr F. Becker.
Signor G. Boccardi.
Prof. I. Bonsdorff.
J. R. Brown, Esq.
Prof. E. W. Brown.
Signor A. Cabreira.
Cambridge University Press.
Señor M. S. de Carmona.
Signor L. Carnera.
Chicago University Press.

Dr. L. J. Comrie.
The Consolidated Gas Company of New York.
H. Crompton, Esq.
— Darling, Esq.
M. G. Delmotte.
M. P. Ditisheim.
Dr. J. L. E. Dreyer.
A. Eagle, Esq.
The Editor of *Říše Hvezd.*
The Editor of *The Year-Book of Wireless Telegraphy and Telephony.*
The Editors of *The Observatory.*
Prof. B. P. Gerasimovič.
H. B. Goodwin, Esq.
J. Haddad, Esq.
Rev. J. G. Hagen, S.J.
Dr. G. E. Hale.
G. H. Hamilton, Esq.
Prof. V. V. Heinrich.
Prof. H. Kimura.
J. Klepěsta, Esq.
Dr. K. Kohl.
Dr. W. J. S. Lockyer.
Prof. H. Ludendorff.
Col. F. C. Molesworth.
Signor M. M. S. N. Neumann.
Herr T. Niethammer.
Dr. C. P. Olivier.
F. G. Pease, Esq.
Prof. W. H. Pickering.
Herr E. Przybyllok.
Capt. J. F. Ruthven.
Dr. H. Seemann.
Herr A. Seydler.
Prof. G. Shajn.
Dr. W. H. Steavenson.
Dr. D. Stenquist.
Miss C. O. Stevens.
Dr. G. Stracke.
Col. F. J. M. Stratton.
J. Tatlock, Esq.
Messrs. Wheldon and Wesley.
Dr. E. Wiedemann.
Dr. A. Wolfer.
Dr. W. H. Wright.

ADDRESS

Delivered by the President, Dr. J. H. Jeans, on presenting the Gold Medal of the Society to Professor Albert Einstein, for his researches on Relativity and the Theory of Gravitation.

Some of us may remember the story of the children who played truant in order to explore the regions where the rainbow ends. After travelling all day, up hill and down dale, they had to admit failure of the most thoroughgoing kind—the rainbow was to all appearances no nearer than when they started. Really scientific children might have thought of estimating their rate of approach to the rainbow by measuring the angle it subtended. If they had measured it in the morning it would have been 42° 23′; it would have been 42° 23′ at noon, and again at night it would still be precisely 42° 23′. If they had done this they must have felt that they were the victims of extreme bad luck, for they had clearly seen the rainbow in front of the nearest hill when they started out; could there be some sort of conspiracy on the part of rainbows, hills, and indeed the whole scheme of nature, to prevent their getting close up to that rainbow?

In the year 1905 the world of physicists was engaged in a pastime which was, in many respects, very similar to that of chasing rainbows. They believed light to travel through an ether with a speed of 300,000 kms. a second. If the solar system were travelling through this ether at a speed of, say, 1000 kms. a second, it would partially overtake light travelling in the same direction, so that this light ought to appear to travel at only 299,000 kms. a second. On the other hand, light travelling in the opposite direction ought to appear to travel with a velocity of 301,000 kms. a second. This suggested an obvious means of discovering both the speed and direction of the earth's voyage through the ether—indeed, it was every bit as obvious as the children's plan for exploring the foot of the rainbow. Experiments were designed to utilise this principle and were tried time after time, not in one form only but in many. And time after time experiment gave the answer that the velocity of the earth through the ether was zero, or at least, to put it in another form which was at that time thought to mean precisely the same thing, the velocity of light relative to the earth was the same in all directions. No doubt it was conceivable that on the occasion of the first experiment the earth really might have happened to be at rest in the ether, but it was quite inconceivable that this should be the case every time; indeed, the earth's orbital motion alone required a variation of some 30 kms. a second, and all the experiments were capable of detecting far smaller variations than this. At first glance it looked as though the earth must be carrying its own private ether about with it, and I suppose this view would have prevailed had it not been for the astronomers, who were ready with an aberration-constant which at once, and, I think, irrevocably, dismissed the possibility of an ether being dragged about with us. Incidentally this episode provides an often overlooked instance of the services of astronomy to the other

sciences and to the growth of knowledge in general. The physicists on Jupiter may still believe that a luminiferous ether exists which follows Jupiter about wherever it goes; the reason is that there are no astronomers on Jupiter to put them right, their permanent blanket of clouds not encouraging this profession.

I forget the end of the story of the rainbow quest, but am prepared to provide an entirely unauthoritative ending. After the children had got completely tired in their bodies and still more completely bewildered in their wits, they rested for a long time, until they encountered a magician. He was not in the least the conventional magician, ponderous of speech and with a long white beard; indeed he was a young man of twenty-six, extraordinarily simple and unassuming in all that he said. What he said in brief was this: "I can tell you what is the matter. You have started to chase the rainbow on the supposition that it is a material arch; in actual fact it is all in your own eyes. Gretchen sees one rainbow, and Hans sees a quite different one. But if Hans walks up to where Gretchen is standing, he simply changes his rainbow for hers; you don't get any nearer to a rainbow by walking this distance, because there isn't really anything for you to get any nearer to. The angle you have been measuring must always stay at 42° 23′; it is fixed there by the unalterable laws of nature, and children can't alter these by walking about." As the children were tired, and the young magician had perhaps expressed himself in rather unfamiliar ways, they didn't at first quite understand what he meant. But then another magician whose name was Minkowski came along, and he made it all seem much simpler; he said it was quite true that each child carried its own rainbow about with it, but that behind the subjective vision of the rainbow was an objective reality consisting of a shower of raindrops. These raindrops were the same for everybody, but out of the whole lot each person's eye selected, or rather the sunshine selected for each person's eye, a small group of drops which appeared to him to form a bright arch. If all space were filled with children standing in different spots, then the aggregate of all the raindrops seen in all the children's eyes would constitute the reality behind the whole phenomenon, a shower of rain. When the second magician put things in this way the children began to understand; they saw that the first magician, whose name was Einstein, had been right.

I doubt if the Society has ever had its Medallist introduced to it in so disrespectful a way before, but my little parable may remind you of the way in which our present Medallist made his entry into the scientific world, and also of the way in which the scientific world made their entry into the changed universe in which science moves to-day. Time and space as separate entities, the time and space we wrote about and thought about previous to 1905, have gone, or, as Minkowski puts it, have become shadows, while only the product of the two remains as the framework in which all material phenomena take place. Time and space separately may mean something to us subjectively, but Nature knows nothing of them until they have been multiplied together into a four-dimensional space-time continuum; it is in this that she has set her laws. If I have seemed to treat Einstein's great

early work too lightly I would plead, first, that it has already suffered enough serious exposition, and, second, that only really great work permits of being treated lightly, and that it is well to take a chance when it offers itself. But let not the lightness of treatment be thought to imply lightness of esteem for the work. By his single 1905 paper, Einstein started a revolution in scientific thought to which as yet we can see no end, to which, indeed, we can hardly yet imagine any end. Had he written only that one paper his position as one of the great figures of science would, in my opinion, have been secure. He would perhaps not have been awarded the Gold Medal of our Society, but that would be because he had not yet become an astronomer.

If the magicians had given the right explanation of the rainbow, then everything the children saw in the rainbow ought to admit of explanation in terms of the ultimate reality provided by the shower of rain. Obviously there would have been something radically wrong if Gretchen had seen a circular rainbow while Hans, standing by her side, had seen a square one; something wrong, too, if Gretchen had said that the colours ran from red to blue as you passed inwards, while Hans said they ran from blue to red. And in the same way if Einstein and Minkowski were right about time and space, there must have been something radically wrong when Isaac Newton had said that every particle in the universe attracted every other particle with a force that varied as the inverse square of the distance, and again when he had said that the path of a planet about the sun was an endlessly repeated ellipse. When the last of these statements, for instance, is expressed in terms of the four-dimensional framework which Einstein and Minkowski regarded as the ultimate objective reality, it is found to make sheer nonsense, to be inconsistent with itself. Viewed in that framework an endlessly repeated ellipse becomes a sort of helical curve, a spiral staircase climbing up into eternity, whose projection on one particular cross-section is the single ellipse in question. View it from any angle you like and it is still a helical curve, but project it on some other cross-section and you will find that the radius vector relative to the sun no longer describes an endlessly repeated ellipse. In brief, the Newtonian law of gravitation could not be true, because it could not be expressed in terms of the ultimate four-dimensional reality in such a way as to be true for more than one person at a time. When our Medallist had this brought to his notice he at once became an astronomer.

His task, rather a heavy one for the first piece of work of a young apprentice to astronomy, was to find out what was the matter with Newton's law of gravitation and to put it right. Of course, in a sense, there wasn't very much wrong: Halley's comet had come back when it was expected, and Jupiter's satellites could be seen every night, exactly as the pictures in the Nautical Almanack predicted that they ought to be seen if Newton had been right, and all the planets seemed actually to be describing endlessly repeated ellipses, except that Mercury wandered very, very slightly from his proper place. And yet, in another sense, there must be everything wrong with a law that didn't fit properly into the four-dimensional reality, or at least there was as much wrong as the difference between truth and error, which the true man of science

regards as the biggest magnitude with which he ever has to deal. And just as Kepler, starting from the established error of eight minutes of arc in the observed position of Mars, had set out "to construct a new theory that will explain the motions of all the planets," so our Medallist set to work to construct a new theory which was incidentally to explain the motion of the planets, but was destined also to change our whole interpretation of the fundamental significance of these motions.

Every astronomer is familiar with this part of Einstein's work. By 1915 he had found the modification needed in Newton's view of gravitation, and had shown that the orbit of a planet, instead of being the impossible endlessly repeated ellipse, was an ellipse which kept slowly turning round in its own plane. He had also found that the theoretically predicted rate of turning for Mercury was exactly the 43″ a century by which Leverrier had found that the planet's perihelion advanced over and beyond the advance caused by the pull of the other planets. He announced two further physical consequences of his theory. Rays of light passing through a gravitational field ought to be bent by a calculable amount, 1″·745 for light which has just grazed the sun's limb ; and spectral lines emanating from atoms in a gravitational field ought to be displaced towards the red, the displacement of lines from the solar photosphere being that corresponding to a velocity of 0·634 kms. a second, or, say, 0·008A at the cyanogen band λ3883. Newton had queried in his optics whether rays of light would bend in obedience to gravitational force, but Einstein was the first since Newton to make any definite physical predictions arising out of a theory of gravitation.

Our two British expeditions put the first of these predictions to the test at the 1919 eclipse, and, as we know, brought back the news that the prediction was amply verified. The testing of the second prediction was a more difficult matter, not so much because the small displacement of 0·008A was difficult to measure as because it was masked by bigger displacements of unknown amount. Even to-day the problem can hardly be said to be solved with absolute finality so far as solar light is concerned, although probably Evershed, St. John, and others have done all that it is possible to do. But the prediction which it was found almost impossible to test by the light of our sun has been tested by the light of one of the faintest of stars. Sirius has as companion a smaller and far fainter star which describes an orbit round it. Its effect on the motion of Sirius shows its mass to be 0·85 times that of the sun, and its distance is for all practical purposes the same as that of Sirius. The amount of light it emits is so small that Seares had calculated its radius to be only about 20,000 kms., or one thirty-fifth of the radius of our sun. Now Einstein's theory predicts a shift proportional to M/r, so that whereas the predicted shift in the solar spectrum corresponds to a velocity of only 0·634 kms. a second, the light from the companion to Sirius ought to show a shift corresponding to a velocity of 20 kms. a second, something like a third of an angstrom. Here then was a shift whose magnitude was suitable for measurement. The measurement was undertaken at Mount Wilson, and the observed shift was found to agree almost exactly with that predicted by theory. This experiment not only established the validity of Einstein's theory

of the gravitational displacement of spectral lines, but also showed its usefulness as an instrument to be utilised by the practical astronomer in his everyday work.

The ultimate importance of Einstein's work was not, however, that it gave astronomers new tools for the measurement of stellar diameters, or for the prediction of the position of Mercury ; it was not even that it gave the true law of gravitation ; it was that it gave a new conception of the meaning of gravitation and of gravitational force. Strictly speaking, Einstein did not amend Newton's law of force ; he abolished it. He put something else of a quite different nature in its place, something which was consistent with itself when looked at in the four-dimensional continuum and which agreed with the observed facts of nature, including the then untested bending and reddening of light. At first he had tried to amend Newton's law to fit the continuum, but he soon found it was a case of amending the continuum so as to fit Newton's law. Or rather, since a perfect fit was impossible, this being the cause of all the trouble, he amended the continuum so as to fit Newton's law in the only region where it could fit, namely, at infinity, and then found that the misfit for nearer distances gave just the needed 43″ a century for Mercury's orbit. And just as completely as, some three centuries earlier, the kinematical explanation of cycles and epicycles had crumbled to nothing in the hands of Kepler and Newton, so now the dynamical explanation of a gravitational force crumbled in the hands of Einstein. The story of this part of our Medallist's work has been so often told and is so familiar to all astronomers that you will hardly wish to linger over it. Let me only remind you that it opened up a path into entirely new scientific territory along which Weyl and others have advanced, attempting, so far as can at present be seen with success, to extend Einstein's fundamental conceptions so as to explain the " forces " of electromagnetism in terms of a still further generalisation of the geometry of the continuum. If they have succeeded, the mechanism of the whole universe is transformed ; dynamics disappear from science, and the laws of nature are those of geometry alone.

We need hardly spend time over the threadbare and rather meaningless question of whether our Medallist has performed the feat of " abolishing the ether." So much depends on what we mean by " ether." As soon as the term is defined, the question as to whether or not that particular ether exists almost answers itself—generally in the negative. The luminiferous ether of Kelvin, Maxwell, and Faraday, largely as the result of our Medallist's new outlook on the universe, may be described as dead ; it is no longer a serious scientific hypothesis, but merely an item in the unscientific jargon of popular expositions of " wireless."

Let us rather spend the few minutes that remain in taking a glimpse at the new universe into which Einstein's work has led us.

Until the seventeenth century the majority of men believed that terrestrial life was the prime reason for the existence of the myriads of stars that lighted the firmament ; they had indeed been created just a few days before man so as to be ready to minister to his pleasure on his arrival. In the twentieth century the majority of men believe that there is a sort of flow of time which is regulated by our consciousness.

We live now in the year 1926, and therefore speak of 1925 as dead and past; 1927 is not yet born but will spring into life for us just as soon as we need it, which will be when we reach the end of 1926. So the traveller journeying west through Devon might suppose that Somerset had fallen out of existence at the moment he left it, and that Cornwall was waiting only for his arrival to come into existence. Foolish, perhaps, when expressed in terms of space, and yet our everyday belief in respect of time.

Einstein's theory eliminates the supposed essential difference between space and time; what is one man's space is another man's time. Not only so, but what is the past in time for one man is the future for another man. According to the view thrust upon us by the theory of relativity, the space-time landscape does not spring into life in front of us and die behind us; it is unalterably there. Existence becomes a picture rather than a drama, and the year 1927 has the same sort of existence as the county of Cornwall. Probably no one would regard this as a final statement of the matter; it goes as far as the theory of relativity carries us, but the theory of relativity is concerned only with inanimate nature; it takes no cognisance of life or consciousness. It is for us to go further if we can.

Does the theory, however, leave room for us to go further? Does it leave room for life and consciousness, and for the attributes, such as free-will, which we attach to them?

The materialistic philosophy of a generation ago used to insist that the picture which science then presented of the universe left no room for such things. That picture has no doubt been torn to shreds, but what about the new picture? Does this look with any more favour on our instinctive belief that we can guide our actions and make the universe in some small degree different by our presence? Or are we mere passive spectators, carried—in a train whose speed we cannot regulate and whose course we cannot alter by an inch—out of a Devon with which we can do nothing except gaze at it through a window, into a Cornwall which is already in existence and has been unalterably created by other hands than ours? To this last question the answer of the theory of relativity would seem to be in the affirmative, but relativity is not the whole of natural science; it is not even the whole of our Medallist's work.

His contributions to science fall into two columns which, unhappily, are parallel and show no signs of meeting. The first column contains his contributions to the Theory of Relativity, the red-letter years being 1905 and 1915; the second column contains his contributions to the Theory of Quanta, the red-letter years being 1905 and 1916. It is not yet altogether clear which of these columns will figure most prominently in the history of present-day science when this is finally written in its proper perspective. But it already seems possible that the second column of our Medallist's work may contain the needed antidote to the determinism and automatonism to which the first column, if it stood by itself, would seem to condemn us.

This room contains, let us say, a thousand atoms of uranium. The chances are that after five million years only 999 of these will be left,

the other one having been transformed into an atom of lead, eight atoms of helium, and about 10^{-27} grammes of radiation or heat. One of the thousand atoms is fated to be transformed in this way, but what determines which particular atom it is to be? Are we tempted to conjecture that it will be that one that gets most knocked about in the interval, or that gets into the hottest places, or what not? If so, we are wrong; for if blows or heat could disintegrate the one atom they could also disintegrate the other 999, and yet every physicist is firmly convinced that no possible treatment can retard or expedite the disintegration of the uranium atoms in the least degree. Once every five million years fate knocks at the door of one atom and it breaks up. Why fate chooses this interval, why she selects one particular atom rather than its fellow we simply do not know; we seem to be beyond the domain of what have heretofore been called natural laws.

Now let us think of a more familiar, although more complicated phenomenon. The hot filament of an electric light bulb receives energy from a dynamo and discharges it as radiation. Inside that filament the electrons of millions of atoms are jumping up and down between different energy levels, and our Medallist has investigated what may be called the statistics of their jumping about. Most of the knocks now are just those of ordinary radiation. The temperature radiation of the filament knocks some electrons up and some down; double the stream of radiation and the electrons will be knocked up and down twice as frequently. But this is not the whole story: if it were, the emission of light from the filament would not be what exact experiment shows it to be. Our Medallist finds that to explain the observed stream of radiation from the filament, fate must be invoked here also. Some atoms are knocked down from the high energy level to the lower because the stream of radiation pushes them down, but others stumble down by processes analogous to those by which the uranium atom disintegrates. They stumble, if you like, of their own clumsiness, or, if you like, because fate beckons them down. Put it anyhow you like, and you will almost certainly be wrong: our Medallist has shown that it happens, and beyond this we know nothing.

But it is, I suppose, clear that we may be in the presence of something here which is quite beyond the inflexible cause and effect of the older mechanics, and possibly equally beyond the precreated tangle of events of the theory of relativity. A single instance will perhaps suggest how far beyond. The lines of the hydrogen spectrum result from the falling down of the electrons of hydrogen from one energy level to another, and in the determination of the wave-lengths represented by these lines the future of the atom enters as an equal partner with the past, although, as we have seen, the future of an individual atom can no longer be regarded as a consequence of its past in the sense in which an effect is the consequence of the cause. We are here in unfamiliar regions of thought where our minds get frozen and refuse to operate. But one thing at least seems possible. It seems as though the deadly inevitability of cause and effect has ended, and we are in the presence of new possibilities of freedom which as yet we do not understand. Our Medallist's work on Relativity changed the universe

from a drama into a picture. It seems possible, as Weyl first suggested, that his work on Quanta may have provided the clue which is destined to change it back again into a drama—no longer a drama in which all the parts have been written and the gestures pre-arranged before the curtain went up, but a drama in which all the actors choose their actions as the play proceeds—in fact, not a staged drama but life. No doubt the great mass of the universe must always follow a predestined path; nothing but predetermined forces can bind the cluster of the Pleiades or loose the bands of Orion or guide the Bear with her train, but there is now, for the first time since Newton, room in the universe for something besides predestined forces. No doubt this is only a possibility, only a conjecture if you like. We do not understand quantum phenomena well enough to go beyond conjectures. Perhaps a hope is dawning that some quite recent investigations of an abstruse mathematical nature are going to provide an answer to the puzzle, but if so it seems probable that the answer will not be in terms of ordinary time and space, and so will come from outside the regions surveyed by the theory of relativity. In any case, it seems that there must be room for much in the universe about which relativity knows nothing. Perhaps the two columns of our Medallist's work, which never clash because they never meet, provide a true symbolical picture of the universe which he has done so much towards elucidating.

We all regret he has been unable to come to receive the Medal in person. We have received the following letter from him:

An die Royal Astronomical Society.

Sehr geehrte Herren,—Wer einen Gedanken findet, der uns wenn auch nur wenig tiefer in das ewige Geheimnis der Natur blicken lässt, dem ist eine grosse Gnade zuteil geworden. Wer dazu noch die Anerkennung, Sympathie und Förderung der Besten seiner Zeit erfährt, der erlangt fast mehr Glück, als ein Mensch ertragen kann. In diesem Bewusts ein danke ich Ihnen in demütiger Gesinnung für die grosse Auszeichnung, deren Sie mich für würdig befunden haben. Gerne würde ich zu Ihnen kommen, um die mir zuerkannte Medaille persönlich in Empfang zu nehmen; leider ist mir dies jedoch nicht möglich.*—Mit ausgezeichneter Hochachtung. A. Einstein.

The medal will be sent to him, and with it, I am sure, goes the most cordial wish of the whole Society that the future may bring with it health, vigour, and further scientific triumphs of the kind that have already made him one of the outstanding figures of modern science, and, I think we may anticipate the verdict of posterity and add, one of the outstanding figures also in the history of human thought.

* He who discovers a line of thought which permits us to penetrate even a little deeper into the eternal mystery of Nature is greatly privileged. He who, in addition, is encouraged by recognition, sympathy and help from the best minds of his time, almost more happiness than one man can bear. In this spirit I thank you from the bottom of my heart for the great honour of which you have found me worthy. I should have wished to come to you in person to receive the Gold Medal, but unfortunately it is impossible for me to do so.

The following Obituary Notice was received too late to appear on the proper page:—

Ernest Elliot Markwick was the eldest son of William Markwick of East Acton, London. He was born in 1853, educated at King's College School, and in 1872 entered the Army, taking part in the Zulu War of 1879, the Boer War of 1880-81, and the Bechuanaland Expedition of 1884–85.

His active military career was a distinguished one. He was mentioned in despatches and promoted for services rendered, attaining the rank of Colonel.

Markwick occupied the position of Chief Ordnance Officer, Cork District, 1887–93; Gibraltar, 1893–98; Western District, 1898–1903; Second Army Corps, 1903–4; and of Assistant Director of Ordnance Stores, Southern Command in 1905, retiring in the same year and receiving the C.B. (military).

Placing his services at the disposal of his country, on the outbreak of the Great War, he was appointed Assistant Director of Ordnance Services at Dublin where he served during the whole war period, being awarded the C.B.E. (military) at the conclusion of hostilities.

Markwick's interest in astronomy may well be described as life-long. He was an original member of the British Astronomical Association (1890), and served as its President from 1912 to 1914. For ten years (1899–1909) he occupied the position of Director of the Variable Star Section of the Association, and it was during this period that his most enduring work was done. At the age of 21, he became the possessor of a little $2\frac{3}{4}$-inch equatorial, and with the help of this and a pair of binocular field glasses he made in subsequent years some thousands of observations of variable stars and of solar phenomena. The life of a soldier, often on foreign service, made systematic astronomical work difficult, but Markwick's interest in his favourite science was always maintained, and he made observations whenever and however he could. In the early nineties he was watching more than sixty stars, variable, or suspected of variability, using for the most part binoculars. Perhaps some of this earlier work was not of great scientific value. Many of the stars observed were variable, if at all, only to a small extent, and when the number of observations obtained during each year was small, no very definite results could be obtained. But all the time he was gaining experience which was to stand him in good stead later on. That he was not slow to profit by his own mistakes is shown by the fact that, when a few years later he was appointed Director of the Variable Star Section, he decided to concentrate the efforts of all the members on a strictly limited number of known variable stars, the majority of which had a considerable range of variability.

About the close of the nineteenth century, variable star astronomy was passing through a critical stage, especially as regards the work done in the British Isles. The older observers, such as Pogson, Baxendell, and Knott had passed away; a considerable number of new variable stars had been recently discovered by Espin and Anderson,

who did not make systematic observations of variables, and the number of stars requiring attention was increasing. Almost the only regular observers in England were Grover and Corder, who used different magnitude scales.

At this juncture Markwick was called upon to direct a little band of workers which under his guidance rapidly sprang into prominence and exerted an influence on the progress of astronomy.

The B.A.A. Variable Star Section had been in existence for some years and three useful reports had been published ; but so far each member had worked independently, his results appearing separately in the report. There was no common plan or uniform method of observation. E. C. Pickering, in America, had called attention to the necessity for co-operation in the observation of variable stars of long period, but little had been done in that direction, and there was no body of observers specially devoted to the work. Markwick saw the need for co-ordination and concentration on a definite common programme, and he set to work to organise the section for systematic work on co-operative lines.

He was well equipped for the task. He had been observing for a good many years and had himself discovered two new variable stars. Alive to what was going on in other parts of the world, he had been quick to realise the importance of Professor Pickering's photometric work, and had early adopted the magnitude scale of the Harvard Photometry. Besides preparing a list of objects for study "embracing the principal types," concentrating attention on these stars, adopting a regular series of magnitudes of comparison stars and a uniform method of recording observations, he introduced several refinements. Observers were instructed to record the G.M.T. of their observations (a point which many omitted), details of the instrument and magnifying power used, the state of the sky and the "class" or weight of each observation, both of the latter on a scale of 1 to 3.

The Director kept in touch with his members by means of circulars, some of which contained instructions or information, others a discussion of the observations of specified stars, light curves, and remarks on the results obtained. During his first three years of office no less than 58 such circulars were issued, and in this way and by the publication of frequent interim reports, interest in the work was maintained. Besides this, Markwick prepared and distributed maps and lists of comparison stars, and carried on much private correspondence with members, helping them in their difficulties, and encouraging them in their efforts; in fact the amount of work he got through is almost incredible.

Some years ago, in addressing a meeting of the British Astronomical Association, Professor H. N. Russell spoke of the rôle which variable stars were playing in the study of stellar evolution, etc. "We [Americans] have now a very efficient organisation for the observation of variable stars," said Professor Russell, "but you were the first, you led the way." We should say Colonel Markwick led the way, for it was due to his foresight, his organising ability and enthusiasm, his untiring energy, and enormous capacity for work, that the Variable Star

Section developed as it did into a really efficient body of workers and a model for future organisations.

As throwing further light on the way in which such good results were achieved, Markwick's earlier reports are specially interesting. His first, *Mem. B.A.A.*, vol. xi, part 3, the report on Nova Persei (1901), commences with a spirited account of the discovery of the nova, reproductions of the telegrams received and despatched to Greenwich, and the first observations made by the director and communicated to the local paper. He then gives the photometric results in the form of a table and a light curve (drawn by Mr. Gore), photographs by Mr. Alex. Smith of Dalbeattie showing the star image with the "aureola" (first detected by Antoniadi), a diagram of the colour changes and visual spectroscopic observations, by Mr. Edwin Holmes, which are valuable as they give information concerning the red end of the spectrum which is lacking in more elaborate photographic investigations. This report covers the whole field and presents the facts in an attractive manner, calculated to foster the interest in this branch of astronomy which the opportune appearance of the nova had aroused.

In his second memoir, 5th of the section, he puts on record the general plan of work, gives the principal results of the first three years' observation, and 23 mean light-curves beautifully drawn by himself and well reproduced. Some may have thought that the time and money spent on this report were out of proportion to the scientific results contained in it; yet it is doubtful whether a similar publication ever produced more valuable results, because it served as a primer and guide to the beginner and prospective observer.

There was a brief description of the several types of variable star, Algol, β-Lyræ, Cepheids, long-period and irregular variables, followed by an account of the results deduced from the observations of individual stars and then the light-curves.

The following report (1906) contains the individual observations for five years and continuous light-curves. Again the objection may be raised that some of the latter were very scrappy; but Markwick knew the value of publicity and the need for publishing the work, good and bad. And it was the worst work which was the most inspiring; those ugly gaps in the curves led some of the younger observers to set to work and prevent them occurring in the future.

In Markwick's case it was not the possession of any one outstanding quality that brought distinction, but rather the happy coincidence of several different qualities. Like a good soldier he was quick to see a chance and take it, but unlike some men of action he was at the same time orderly and methodical in his work, and capable of a long-sustained effort. When stationed at Gibraltar, where he arrived in May 1893, he took advantage of his geographical position "to attack the zone $27\frac{1}{2}^\circ$ to 45° S. Dec., using binoculars, and comparing the sky with the U.A." This search led to the discovery of two remarkable variable stars: T. Centauri, for many years considered as the shortest long-period variable; and RY Sagittarii, then the only star known to resemble R Coronæ and still the next brightest of that peculiar class. Two other

stars, S Sculptoris and RR Sagittarii, were discovered independently by Markwick, and at Harvard.

Again, when called upon to direct the B.A.A. Variable Star Section at a critical time, he saw the opportunity for doing good work and took full advantage of it, bringing to bear on the task all his qualities and accomplishments, from his ability as a lineal draughtsman to that understanding of human nature which made him always so ready to recognise and publicly acknowledge any specially good piece of work, and so foster a spirit of friendly rivalry among his followers.

On retiring and fixing his residence near Bournemouth, Markwick mounted an $8\frac{1}{2}$-inch altazimuth reflector which he used in place of the $2\frac{3}{4}$-inch for the observation of variable stars; and some years later a 4-inch equatorial refractor for solar observation, which occupied him much at that time. The great wealth of detail and variety of form presented by sun-spots appealed to him as an artist as well as an astronomer. He contributed to the Solar reports of the British Astronomical Association, and until shortly before his death his monthly notes appeared regularly in the *English Mechanic*.

Markwick was much attracted by the broader open-air phenomena of nature, such as the zodiacal light, of which he made many observations in his latter years, and the optical phenomena of the atmosphere. The beauty and wonder of nature appealed to the man, who was a careful observer, a methodical compiler of facts, and an enthusiastic and cheerful leader of those who worked with him.

In 1882 Colonel Markwick married Amy, only daughter of F. M. Murton, Esq., of Natal, who survives him with two sons and a daughter. He died on 1925 July 4.

He was elected a Fellow of the Society on 1879 March 14.

P. M. R.

Election of Officers and Council.

The following Fellows were elected as Officers and Council for the ensuing year :—

President.

J. H. JEANS, Esq., M.A., D.Sc., LL.D., Sec. R.S.

Vice-Presidents.

J. L. E. DREYER, Esq., M.A., Ph.D., D.Sc.
Sir FRANK DYSON, M.A., LL.D., F.R.S., Astronomer Royal.
J. W. L. GLAISHER, Esq., Sc.D., F.R.S.
Rev. T. E. R. PHILLIPS, M.A.

Treasurer.

Lieut.-Col. F. J. M. STRATTON, D.S.O., M.A.

Secretaries.

JOHN JACKSON, Esq., M.A., D.Sc.
H. KNOX-SHAW, Esq., M.A., Radcliffe Observer, Oxford.

Foreign Secretary.

H. H. TURNER, Esq., D.Sc., D.C.L., F.R.S., Savilian Professor of Astronomy, Oxford.

Council.

A. C. D. CROMMELIN, Esq., B.A., D.Sc.
HERBERT DINGLE, Esq., Asst. Professor of Astrophysics, Imperial College of Science and Technology, South Kensington.
A. S. EDDINGTON, Esq., M.A., M.Sc., LL.D., F.R.S., Plumian Professor of Astronomy, Cambridge.
ALFRED FOWLER, Esq., F.R.S., Yarrow Research Professor of the Royal Society, Imperial College of Science and Technology, South Kensington.
P. H. HEPBURN, Esq., LL.B.
HAROLD JEFFREYS, Esq., M.A., D.Sc., F.R.S.
E. B. KNOBEL, Esq.
E. A. MILNE, Esq., M.A., Beyer Professor of Applied Mathematics, University of Manchester.
H. F. NEWALL, Esq., M.A., D.Sc., F.R.S., Professor of Astrophysics, Cambridge.
JOHN H. REYNOLDS, Esq.
W. H. STEAVENSON, Esq.
HAROLD THOMSON, Esq., M.Sc.